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GOVERNMENT OF MADRAS

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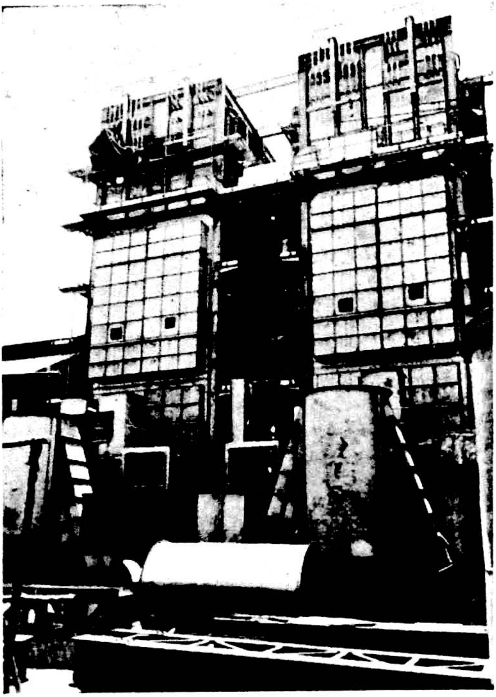

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JOURNAL

OF THE ELECTRICITY DEPARTMENT

GOVERNMENT OF MADRAS

VOL. XI JANUARY—MARCH 1957 No. 4

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MADRAS

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The Ontario Hydro-Electric Power Commission

[*Extracts from the Report of Sri V. P. Appadurai, B.A.M.I.E. (Ind.), Chief Engineer for Electricity.*]

THE AUTHOR

THE AUTHOR WAS DEPUTED by the State Government, under the Colombo Plan Fellowship to the Dominion of Canada and the United States of America, to make a study of the Power Schemes in operation in the two places. A small description of the history of origin, power station capacities, administration and programme of development of the Tennessee Valley Authority in United States of America was given by the Author in a previous issue of the Journal. The Shawinigan Water and Power Company and the Ontario Hydro-Electric Power Commission together supply the whole of the power requirements of South-east Canada, the most industrially advanced area in the whole Dominion.

A brief account of the formation, power station practices and organization of the Ontario Hydro-Electric Power Commission is given in this article.

1. History of the Commission.

The Hydro-Electric Power Commission of Ontario, now a corporate body, administering a province-wide co-operative enterprise, producing and distributing electric power, was incorporated in 1906 by an enactment of the Ontario Legislature on the recommendations of the advisory commission appointed to determine ways and means, for the conservation of the water power resources of the Province, and its utilization for the benefit of all its people. The Commission functions as an independent self-sustaining public concern endowed with broad powers to generate, purchase and distribute electric power and to perform certain regulatory functions with respect to the activities of the electrical utility commissions of the member municipalities.

* This article is compiled by Sri S. Raman, Assistant Engineer (Electrical).

The position of electric power development in Ontario before the formation of the Commission was briefly as follows :—

The Niagara Falls Power Company had undertaken its first major electric power development at Niagara Falls, New York, in 1893, power being generated at 25 cycles. The Canadian Niagara Power Company came into operation in 1905, and was followed by the Ontario Power Company in 1906, both operating from the waters of the Niagara river at the neighbourhood of the falls and generating power at 25 cycles. A large part of its output was being transmitted initially by the Power Company to New York on the opposite bank of the river and to Toronto, about 90 miles away.

At the outset of its operation, the Ontario Hydro-Electric Power Commission proceeded to construct transmission lines to supply the Niagara power to the municipalities, which first came into partnership with it. As the years passed on and its financial structure became strong, the Commission finding itself hard pressed for supply, found it necessary to itself enter the field of generation, and construct huge hydro-electric schemes, to enable it to keep pace with the rising demand for power.

Starting with the purchase of the plants of the Toronto and the Ontario Power Companies on the Niagara river during the first World War, the Commission had, by a well-planned programme of development, as many as 54 generating stations with an installed capacity of about 1,720,000 horse power under its control by end of 1945.

Capacities of a few hydro stations, acquired by the Commission are given below :—

Station.	*Installed capacity.*	*Horse-power.*
Nipigon	6 × 12,500	75,000
Alexander	4 × 18,000	72,000
Abitibi Canyan	5 × 66,000	330,000
Ear Falls	2 × 5,000 plus 2 × 7,500	25,000
Barret Chute	2 × 28,000	56,000
Ranney Falls	2 × 5,000	10,000

The Commission has now in its charge 65 hydro and 8 steam stations. Power is being purchased, besides, from many other companies, as well, the chief of them, being the Gatineau Power Company, the Beauharnois Power Company and the Quebec Power Company, who supply about 340,000 horse power : 300,000 horse-power : and 290,000 horse power respectively.

2. Progress of Power Development by the Commission.

The Queenston Development with an installed capacity of 525,000 horse power was completed in 1925. In 1943, the Decew Falls Development utilizing the waters of the Welland canal came into operation with a capacity of about 190,000 horse power.

The other important projects completed and envisaged by the Commission are given below :—

Scheme.	*Generating capacity in M.W.*	*Hydro or steam.*	*Year of commission.*
Decew Falls	2 × 57	Hydro.	1947
Stewart Ville	68	Do.	1948
Aguasabon	40	Do.	Do.
Hamilton	63	Steam.	1950
George Rainer	42	Hydro.	Do.
Pine-Portage	93	Do.	1954
Des Joachims	380	Do.	1950
Chenaux	120	Do.	Do.
Otte-Holdon	204	Do.	1952
Niagara No. 2	900	Do.	1954
J. Clerk Keith	264	Steam.	..
Richard Hearn	400	Do.	1951

In December 1951, the all system primary peak demand was 4,111,300 horse power and by December 1955, this is expected to be around 5,771,600 horse power.

The smallest stations owned by the Commission are Ear Falls, which is an acquired station with just two units each of 5,000 horse-power and *two units of* 7,500 horse power: and Ranney Falls with just two units of 5,000 horse power alone: while the biggest is Niagara II with 12 units of 105,000 horse power totalling 1,260,000 horse-power.

3. Major Hydro Developments.

The major hydro stations in charge of the Commission are included in the multi-projects of—

(*a*) Niagara River Power Development, and

(*b*) Ottawa River Power Development.

Aguasabon, Decew Falls, George Rainer and Pine Portage are important individual Schemes owned by the Commission.

MAIN FEATURES OF SCHEMES.

With a catchment area of 260,000 and 56,000 square miles, and discharges averaging 210,000 and about 30,000 cusecs respectively, the Niagara and Ottawa River Valley Schemes have a total installation capacity of about 2·2 million horsepower at Queenston, Niagara II, ntario and Toronto Stations together for the former; and 1·2 million horsepower at Locave, DesJoachims, Chenaux, and Chats Falls Stewart Ville Stations together for the latter. While full water flow is utilized in the Ottawa development for geneation of electricity, only a flow of 65,000 cusecs is so utilized in the Niagaraev Delopment. With respect to the Niagara river, actually no attempt is made to dam across, store up and make full use of the water for hydrogeneration. Power development is regulated by an agreement between the United States and the Dominion of Canada (as the river is inter-State) which provides for a river flow of 50,000 to 100,000 cusecs being maintained at the falls to preserve its scenic beauty

and the beauty of the locality. For the various schemes developed on the Niagara, some portion of river flow is diverted into a canal and lead through conduit pipes to the power plants. The projects under the *Ottawa River Development*, as well as the individual schemes of Decew Falls, Pine Portage and Aguasabon, etc., follow the normal pattern of having a storage dam across the river, and a suitable number of penstocks leading to power house. With respect to the Lacave and Chenaux power stations, they are *constructed integral with the dams*, and water is conveyed direct to the scroll case; while for other stations, water is diverted to a forebay: and the penstocks lead from the forebay to the generating plants.

Three systems as indicated below are now in operation:—

(i) Southern Ontario System, serving older and more popular parts of Ontario.

(ii) Thunderbay System serving the North-western shore of Lake Superior.

(iii) Northern Ontario System, which embraces both the North-eastern region and the North-western region excluding the Thunderbay System. Within this region, lie the districts of Nippising, Sudbury, Manitoulin, Algoma, Chochrane and Patricia.

Systems (i) and (ii) serve a group of municipalities receiving power at cost under contracts established according to the provisions of the Power Commission Act. The Commission also serves directly certain industrial consumers and rural consumers within these systems. An area of 363,280 square miles is served by the Commission.

The basic principle governing the financial operations of the undertaking is that electrical service is provided by the Commission to the municipalities and by the municipalities to the customers at cost.

The Commission has two distinct phases of operation. The first phase of operation is the provision of power, either by generation or purchase, and *its transmission* and delivery in bulk to individual municipal utilities, to large industrial consumers and to rural power districts.

The second phase of operation is the retail distribution of electric power to consumers in the areas served by the various municipalities and throughout the rural areas of the Province. For the consolidated rural power districts, the Commission not only provides power in bulk but also attends *to all physical* and financial operations connected with the retail distribution of energy to the consumers.

POWER STATION DETAILS:

Details of the Developments and Schemes undertaken by the Commission are given in brief below:—

(1) The Niagara Power Development on the Niagara river, consisting of Queenston (Niagara No. 1), Sir Adam Beck (Niagara No. 2), Ontario and Toronto power stations.

(2) The Ottawa River Development on the river Ottawa, consisting of Lacave, Des Joachims, Chenaux, Chats Falls and Stewart Ville power stations.

(3) Pine Portage power station on the Nipigon.

(4) Decew river falls power station in Niagara region.

(5) Aguasabon power station above Lake Superior.

The capacities of the stations are given below :—

	Capacities in M.W.
Niagara Development—	
Queenston	450
Niagara II	950
Ontario	145
Toronto	90
	1,635
Ottawa Development—	
Lacave	204
Les Joachims ..	380
Chenaux	120
Chats Falls	180
Stewart Ville ..	61
	945
Other Stations—	
Pine Portage ..	95
Decew Falls	115
Aguasabon	40
	250

Full details of these Schemes are given later in this article. The Technical Characteristics of the power stations are given in Table 1 appended and Design Features of generation in Table 2.

4. Main Thermal Schemes.

The Commission has constructed three thermal power stations to take care of system peak and low water condition of hydro-stations. They are as under :—

(1) Richard L. Hearn Power station with 400 M.W. capacity.

(2) J Clerk Keith Power station with 264 M.W. capacity.

(3) Hamiltons Power station with 63 M.W. capacity.

Hamilton is comparatively a small thermal station. Details of the Richard Hearn and Clerk Keith Power station are given later in this article.

5. Financial Statistics of the Commission.

ASSETS OF THE COMMISSION.

The total assets of the Commission on December 1951 amounted to $ 1,036 million, after deducting the accumulated depreciation of $ 117 million. Rural assets under administration at the end of the year amounted to $ 127 million, of which $ 63 million, has been provided by the Provincial Government in the form of grants-in-aid.

POWER GENERATED AND PURCHASED.

The power generated (peak) and purchased in December 1951 by the Commission was as follows :—

(1) *Southern Ontario System—*

	K.W.
Commission's generating stations.	1,686,150
Power purchased ..	703,100
	2,389,250

(2) *Thunderbay System—*

Commission's generating stations.	234,000
Power purchased ..	1,100
	235,100

(3) *Northern Ontario System—*

Commission's generating stations.	317,400
	317,400
Total power generated and purchased.	2,941,750

The details of power purchased are tabulated below ;—

Sources of purchased power.	1951.
(a) SOUTHERN ONTARIO SYSTEM—	K.W.
Canadian Niagara Power Company.	15,000
Polymer Corporation.	22,000
Gatineau Power Company.	254,000
Ottawa Valley Power Company.	85,000
Beauharnois Power Development.	187,000
Maclaren Quebec Power.	138,000
Miscellaneous ..	2,100
Total ..	703,100
(b) THUNDERBAY SYSTEM.	
Ontario Minesota Pulp and Paper Company.	1,100
Total power purchased for the two systems.	704,200
Total power generated in the two systems.	2,237,550
Total power generated and purchased by the Commission for all the three systems.	2,941,750

CONSUMERS SERVED.

The total number of consumers served by the Commission by the end of 1951 was 1,249,366 : out of which 318,606 were rural consumers.

6. Organizational set-up of the Commission.

The functions of the various divisions of the Commission are briefly as follows :—

I. SUPPLY DIVISION.

This comprises of Purchasing, Supply Control, Supply Inspection, Surplus Equipment and Materials, and the Printing and Stationery Departments.

II. PLANNING DIVISION.

This is responsible for—

(*a*) the maintenance of up-to-date information on potential sources of power ;

(*b*) the preparation of overall engineering plans, and design of the component parts of the power systems including generation, transmission and distribution of power ;

(*c*) analysis of system performance characteristics and liaison with the operations division regarding improvements and modifications to the existing systems ;

(*d*) liaison with the municipalities and direct contract consumers regarding new or increased system facilities ; and

(*e*) provision of technical advice and assistance to the Engineering and Operations Division.

III. CONSUMERS SERVICE DIVISION.

This division comprises of six departments as follows :—

(*a*) The Municipal service department ;

(*b*) Rural service department ;

(*c*) Industrial service department ;

(*d*) The Rate Study department to study the requirements of the consumers, vis-a-vis the existing rates and to forward from time to time recommendations as to changes

in rates necessary to provide adequate revenues with maximum benefit to the consumers;

(e) Statistical department to collect data, to study load conditions, growth trends and matters of similar nature; and the

(j) Electrical inspection department

IV. PUBLIC RELATIONS DIVISION.

This division comprises of five departments as follows:—

(a) Frequency standardization department;

(b) Graphic departments to look after advertising, display, production, photography, etc.

(c) Administration department for the collection of information and preparation of surveys;

(d) Service department for liaison works, preparation of technical films and journals; and the

(e) Editorial department.

(V) COMPTROLLER'S DIVISION.

This comprises of the following:—

(a) Treasury department;

(b) Accounting department;

(c) Internal audits department;

(d) Insurance department; and the

(e) Pension department.

About 2,339,000 h.p. of power in the Southern part, covering on area of about 12,000 square miles, is of 25 cycle supply. Twenty-five cycle supply has now practically been superseded by 60 cycles in the United States of America and in Eastern and Northern Ontario, so that the Southern part of Ontario is now a 25 - cycle island which makes inter-connexion with other systems difficult and costly.

The Commission is changing over all supplies gradually to 60 cycle through a special division called the Department of Frequency Standardization.

V. RESEARCH DIVISION.

The Commission maintains a research division as part of their engineering branch. The Commission felt even at the start that research and testing facilities would be essential, to ensure efficient growth, and to assist in providing continuous electric power at economic rates. A research laboratory was set up in 1912, six years after the Commission was established. The laboratory has a staff of about 300 members occupying more than 70,000 square feet of floor-space. Facilities are available in the laboratory to provide for electrical, mechanical, structural, chemical and metallurgical investigation and testing for all phases of the Commission's operations. The laboratory is one of the largest and best equipped in Canada and is recognized both nationally and internationally as an authority in several fields relating to generation and distribution of electrical energy.

The research division is primarily a service organization maintained to provide specialised advice and highly technical assistance for all other divisions within the Commission. It is responsible for the development, standardization and control of all testing procedure, technical information relating to specifications and for the Commission's scientific and engineering research.

The main problems dealt with by the research divisions are as follows:—

(1) Transmission and distribution problems including those of making satisfactory conductor joints and connections;

(2) Grounding problems;

(3) Linascope-radar type instrument for locating faults on telephone and power lines;

(4) Bolometer for measuring infra-red radiation to survey transmission line joints, to determine if any are operating at abnormal temperatures;

(5) Soniscope, an ultrasonic device to indicate the depth of cracks in concrete structures and also the conditions of the concrete *in situ*;

(6) Investigation of telephone, radio and television interferance problems;

(7) Single pole reclosing of high voltage systems and field forcing on large synchronous condensers;

(8) Problems of accuracy in all billing meters;

(9) 'Hipot' bushing tests for testing of insulators and bushings.

(10) Vibration of conductors;

(11) Transformer oil.

NEW POWER PROJECTS

To meet the rising demand for power after the war, the Commission has had to consider a number of power development schemes. Of these, the most important scheme is the St. Lawrence power project, which is designed and constructed by the Commission jointly with the New Yory State Power Authority. This project is located at the Barnhart Island, and utilises the flow of the inter-state St. Lawrence river for power development. The capacity of the scheme will be 2·2 million h.p. or 1800 M.W. half of which will belong to the Commission. The project stands out in its high magnitude and stupendous conception and has many electrical features that are note-worthy. The chief features are—

(1) Water-cooled main power transformers,

(2) Reduced basic insulation levels for main power transformers,

(3) Isolated-phase bus for generator main leads,

(4) High voltage 115 KV and 230 KV pipe type cable for connections from main power transformers to switchyard,

(5) All aluminium buses in switchyard,

(6) Automatic starting and synchronizing of generators for control room,

(7) Plastic prismatic lens luminous ceiling in control room, and

(8) Mercury vapour lighting in switchyard.

The power plant will have 32 generating units, 16 on the American side and 16 on the Canadian side. The generators will have a name-plate rating of 57 MW or 60 M.V.A. at 0·95 p.f. and will operate at 94·73 rpm. 13·8 KV, 3 phase load. The project would cost 562 millions and is scheduled to be completed in 1964.

(continued in next issue of the Journal.

TABLE 1.—*Technical characteristics of Generating Stations.*

Name of stat	acave.	Des Joachims.	Chenaux.	Stewart Ville.	Chats Falls.	Niagara number 1.	Niagara number 2.	Ontario.	Toronto.	Pine Portage.	Decew Falls.	Aguasabon.
	. . . . Ottawa River Developments	. . . .			.)	(Niagara River Developments	. . . . . .)	(. . . . . .)			Well and River.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1 Date of installation	1950/52	1950/51	1950	1948	1933	1922–25	1950–51	1902	..	1950	1947	1948
2 Total discharge in cusecs ..	18,800	20,700	23,050	6,500	45,000	14,000	40,000	..	..	..	..	..
3 Number of units installed	8	8	8	3	8	10	12	16	11	2 present .. 4 ultimate ..	2	2
4 Discharge per unit in cusecs	4,500	4,950	5,000	..	5,300	..	..	..	..	..	2,700	..
5 Length of penstock in feet	..	195	..	227	..	383	..	..	..	170	402	1,800
6 Material of penstock	Concrete	Steel	Concrete	Steel	Concrete	Steel	Steel	Steel	Steel	Steel	Steel	Steel
7 Diameter of penstock	..	22	..	14	..	16 feet ..	..	9	..	20	16·5	16
8 Number of supply conduits per unit ..	2	1	1	2	3	..	..	1	1	2	1	..
9 Number of penstocks	..	8	..	3	..	10	12	16	11	2/4	2	1
10 Head in feet	77	130	40	148	38–58 feet ..	294	294	175	135	105	280	20
11 Type of inlet valve	..	..	..	..	..	Johnson valve.	..	..	Head gates serve as inlet valves.	Head gates only.	Head gates only.	..
12 Make of turbine	4–Allis chalmers 4 E.E. Co.	Dominion ..	Engineering ..	Allis Chalmers ..	Dominion ..	..	..	..	William Cramp.	Allis chalmers ..	Allis Chalmers ..	Dominion Eng neering.
13 Type of turbine	Reaction ..	Reaction ..	Fixed Blade Propeller.	Reaction ..	Fixed blade propellsr.	Vertical reacticn.	..	orizontal win re-ction.	Vertical reaction.	Vertical reaction.	Vertical reaction.	Reaction ..
14 Rating of turbine (H.P.)	34,400	62,000	21,000	28,000	28,000	55,000 58,000	105,000	..	7–15,500 4–13,000	41,000	77,000	27,500
15 Speed (R.P.M.)	94·7	105·9	94·7	163·6	125	187·5	150	187·5	250	109·1	150	257
16 Make of generator	Westing-house ..	Westing-house ..	C.G.E.	C.G.E.	Westing-house.	..	6–G.E. 6–Westing-house.	..	..	Westing-house ..	General Electric.	Westing-house ..
17 Rating of generator (K.V.A.) ..	27,000	50,000	17,000	24,000	†23,000	45,000 50,000	80,500	30,000 (K.W.)	..	33,000	64,000	22,500
18 Thrust bearing type	Kingsbury pivottedpad.	Kingsbury pivotted pad.	Spring type ..	Spring type ..	Kingsbury ..	..	..	..	..	Kingsbury pivotted pad.	Kingsbury, spring type.	..
19 Whether above or below rotor ..	Umbrella ..	Conventional ..	Conventional ..	Conventional ..	Conventional.	..	G.E.—Conventional. Westing-house umbrella.	..	..	Conventional ..	Conventional ..	Conventional ..
20 Runaway speed (R.P.M.)	170	195	210	280	260	345	250	..	..	215	310	500
21 WR2 of the unit	$39·0 \times 10^6$	60×10^6	$24·0 \times 10^6$	$10·0 \times 10^6$	18×10^6	$21·7 \times 10^6$	$45·0 \times 10^6$	..	..	40.3×10^6	..	$4·9 \times 10^6$
22 Length of the P.H. in feet	..	590	..	..	499	590	..	..	..	175	..	..
23 Width of the P.H. in feet	..	58	..	..	70	135	..	..	..	60	..	..
24 Height of the P.H. in feet	..	65	..	..	53	180	..	..	..		..	..
25 Spacing between units in feet	..	60	62	..	62	60	..	..	..	60	48	35
26 Number of floors	..	4	4	..	..	9	..	..	..	4	..	5
27 Difference in level between centre line of distributor and minimum tail level-feet.	..	8	4·5	2	5	9	..	15	..	7	7	4·7
28 Neutral of the generating unit	Grounded through 50 KVA. Transformer.	Grounded through 50 KVA, Transformer.	Grounded through 37·5 KVA.* Transformer.	Grounded through 25 KVA. Transformer.	Insulated ..	Insulated ..	Grounded through 25 KVA. Transformer.	Insulated ..	Insulated ..	Through 50 KVA. Transformer.	Through a potential transformer.	Through 50 KVA. Transformer **.
29 Transformer H.T. neutral	Solidly grounded.	Solidly grounded.	Solidly grounded.	Solidly grounded.	Solidly grounded.	Through a water rheo.	Solidly grounded.	Through a water rheostat.	..	Solidly grounded.	Through a water rheo.	Solidly grounded.

* The resistor is 367 amps, 36 ohm. 5 min. rating.

† Resistance 0·22 ohms.

TABLE 2—*Design features of generators.*

ONTARIO HYDRO-ELECTRIC COMMISSION.

	Lacave or Otto Holden.	*Des Joachims.*	*Chenaux.*	*Stewart Ville.*	*Chats Falls.*	*Niagara No. 1*	*Niagara No. 2*	*Ontario P.H.*	*Toronto P.H.*	*Decew Falls.*	*Pine Portage.*	*Aguasabon.*
	Ottawa River Developments					(Niagara River Development)						
1-A Maker's name and country	Westinghouse.	Westinghouse.	G.E.	G.E.	Westinghouse.	G.E. & Westinghouse.	G.E. & Westinghouse.	..	..	CGE.	Westinghouse.	Westinghouse.
1 Number of units	8	8	8	3	8	10	12	16	11	2	2/4	2
2 Unit capacity	27,000 KVA.	50,060 KVA.	17,000 KVA.	24,000 KVA.	23,000 KVA.	1—5 = 45,000 KVA. 6 & 10 = 55,000 KVA. 7—9 = 54,000 KVA.	80,500 KVA.	14—10,640 KVA. 2—15,000 KVA.	7—10,000 KVA. 4—8,000 KVA.	64,000 KVA.	33,000 KVA.	22,500 KVA.
3 Power Factor	0·95	0·90	0·95	0·85	0·85	0·8 to 0·9	0·95	..	..	0·80	0·90	0·90
4 Voltage—KV.	13·8	13·8	13·8	13·2	13·2	12•	13·8	12	12	13·8	13·8	13·8
5 Speed—RPM.	94·7	105·9	94·7	163·6	125	187·5	150	..	..	150	109·1	257
6 Reactance, direct—per cent	52·0	195·0	92·8	99·0	..	..	97·1	..	..	..	96	90·0
7 Reactance, quadrature—per cent ..	31·5	60·0	60·4	59·0	..	..	61·1	.	..	..	60	55·0
8 Negative sequence reactance—per cent ..	24·5	36·0	35·4	31·5	..	..	24·5	..	..	..	32·5	33·0
9 Zero sequence reactance—per cent ..	20·0	25·0	11·9	8·3	..	..	11·0	..	..	..	17·0	16·5
10 Transient reactance per cent	30·0	38·0	32·8	35·2	32	..	20·8	..	..	..	34·0	36·0
11 Subtransient—$\frac{X.q''}{X.d''}$	1·4	1·4	1·553	..	..	..	1·4	..	..	..	1·32	1·2
12 Short circuit ratio	2·25	1·31	1·23	1·15	1·34	..	1·2	..	..	..	1·213	..
13 WR2	39·0 × 10^6	62·8 × 10^6	24·0 × 10^6	13·5 × 10^6	18·0 × 10^6	21·7 × 10^6	45·0 × 10^6	..	..	..	36 × 106	5 × 106
14 Inertia constant	3·1	2·9	3·0	..	..	..	..	.	..	..	..	..
15 Capacity of the main exciter	265 KW.	330 KW.	160 KW.	145 KW.	200 KN.	150—180 KW.	325 KW.	..	..	..	175 KW.	130 KW.
16 Voltage of the main exciter	250 V.	250 V.	250 V.	250 V.	250 V.	250 V.	250 V	..	..	..	250 V.	250 V.
17 Ceiling voltage	350 V.	330 V.	360 V.	350 V-400 V.	300 V.	..	350 V.	..	..	..	340 V.	340 V.
18 Voltage of response	300 V/Sec.	300–350/V per second.	189·5 V/Sec.	180 V/Sec.	520 V/Sec.	..	100 V/Sec.	..	..	..	315 V/Sec.	270 V/Sec.
19 Ratio of response	1·0	1·0	1·0	..	..	..	1·0	..	..	..	1·5	1·0
20 Capacity at OP.F. under excited; i.e. line charging capacity.	..	40,000 KVA.	17,000 KVA.	20,000 KVA.	23,500 KVA.	..	80,000 KVA. (90 per cent)	..	..	..	29,700 KVA.	20,000 KVA.
21 Capacity of O.P.F. over excited, i.e. condenser capacity.	12,000 KVA.	30,000 KVA.	10,009 KVA.	..	..	..	44,000 KVA. (45 per cent)	..	..	..	20,000 KVA.	..
22 Damper winding	Non-continuous.	Non-continuous.	Non-continuous.	Non-continuous.	Non-continuous.	..	Non-continuous.	..	..	Non-continuous.	Non-continuous.	Non-continuous.

Forecast of Annual Flow of River Cauvery at Mettur

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THE AUTHOR

1. Synopsis

IN THE ARTICLE on "Weather and Electric Power Systems" in Madras Electricity Department Journal, April-June 1951 issue, a forecast of the annual flow of river Cauvery was given by the Author for a few years based on the data of river flow at Mettur Dam available for a period of 34 years from 1916 to 1949. A cycle of 27 years was deduced. As the author finds that this has evoked much interest, the study has now been extended to cover the data for a further period of six years 1950–55, now available.

The present study confirms the existence of the 27 years cycle, previously deduced. There is of course a small variation of about 20 per cent in the forecasts from the actuals, but it has to be borne in mind that the figures of river in-flow on which the deductions were based, did not take into consideration the storage on the river at Sivasamudram in Mysore State, which can easily account for a 10 per cent variation of the average annual in-flow and also the variable quantity of water stored and used for irrigation in Mysore State, through the Irwin Canal Systems, which can account for a further variation in the forecast.

In spite of these drawbacks the resemblance between the two cycles is very close. It is significant that the correlation factor between the two cycles of 27 years is nearly constant being about 0·59 and the standard deviation is limited to 18 per cent. By linking the two cycles, it is possible to forecast that the year 1957 will be a drought year, the in-flow being less than 306 × 1,000 m.c.ft. In-flow in 1958 will be above the average and be about 490 × 1,000 m.c.ft. The years 1959 and 1960 will be years of heavy in-flow, in excess of 450 and 530 × 1,000 m.c.ft. respectively.

To be fore-warned is to be forearmed. The author would suggest that suitable food stocks be built up in the State to meet possible shortages due to drought and floods between the years 1957–1960.

An additional storage of 20–30 × 1,000 m.c. ft. is a feasible proposition and may be effected by an increased storage at Mettur by raising the dam 10 feet and construction of a reservoir at Hogenakkal in Mysore State. Such construction in the opinion of the author would permit early commencement of the irrigation season and help to cover the failure of the north-east Monsoon.

2. Study of in-flow cycles

Figures of total annual flow of River Cauvery at Mettur Dam from 1916 to 1955 are given in Statement 1 enclosed.

Two cycles of 27 years apart are now available for study, of which the last 13 years can be studied against a similar period of the first cycle. The close resemblance between the two cycles becomes apparent on plotting the flow figures of cumulative in-flow of second cycle against first cycle in graph—vide sketch enclosed. The points fall closely on a straight line with an approximate ratio of 1·27 between the two periods. The ratio is deduced in Statement 1.

The ratio is fairly true for the total flow for the 13 years in the two cycles and also fairly true for any four or more consecutive and corresponding *years in the two cycles.* Individually any one year in one cycle varies with the corresponding year in the other cycle from 100 to 150 per cent : and varies from the average ratio of 1·27 by a maximum of 25 per cent up or down. There is a strong correlation between the two cycles. The correlation ratio is deduced to be 0·59 and Standard deviation works out to 18 per cent. *Details are* furnished in Statements 2 and 3 enclosed. In comparing two cycles, two factors have to be kept in mind, that are responsible for a variation of river in-flow at Mettur Dam. The impounding of water in the Krishna Raja Sagar, which is about half the Mettur Reservoir in capacity, can cause a variation of even 15 per cent in the observed average annual flow of river Cauvery at Mettur, and also a further variation can happen due to the drawal of water through the irrigation systems in Mysore. The drawal of water from Cauvery at Mysore is not a simple proportion of total flow but a variable fraction depending on the rate of discharge, based on an agreement between the two States, which was also probably revised during the period under review. In spite of these variables, the two cycles bear such close resemblance that it cannot be a chance coincidence. The small variations between the actual and the forecast figures are also explained by these.

Since valuable statistical information for a period of 40 years is now available, a further study has now been made and Statements 2 and 3 prepared. It is now possible to make the following deductions :—

The average annual flow for the last 40 years (1916 to 1955) is about 336 × 1,000 m.c.ft. Assuming normal distribution, the Standard deviation is about 100 × 1,000 m.c. ft. and expressed as a percentage it is about 30 per cent.

The average annual flow for 27 years (1916 to 1942) is 325 × 1,000 m.c. ft. Standard deviation is 103 × 1,000 m.c.ft. or 31·8 per cent.

The average annual flow for 27 years (1929 to 1955) is 360 × 1,000 m.c. ft. Standard deviation 103·4 × 1,000 m.c. ft. or 29 per cent.

Hence, it may be seen that the Standard deviation, as a percentage, is practically same for 27 years or 40 years.

Now with an average of 346 and a Standard deviation of 100, it may mean that for 67½ per cent of the years, the flow can be anything between 246 × 1,000 m.c.ft. and 446 × 1,000 m.c. ft. A flow of 246 × 1,000 m.c.ft. will mean a year of failure and near drought condition, while 446 × 1,000 m.c.ft. wil mean a year of high flow. For 95 per cent of the years, the in-flow figure will be between 146 to 546 × 1,000 m.c.ft. which will be still wider. It can be deduced from the above, that we may expect severe floods twice in about 15 years, and severe droughts twice in the same period of 15 years on the average. But the figures do not help us to forecast the probable flows for ony particular year.

On the other hand, the deductions of the trends and cycles linking the two periods gives us scope to assess the flow in individual years.

IN-FLOW FORECASTS.

By linking, the first 13 years of the I cycle to similar 13 years of the II cycle, the Standard deviation works out to only 18 per cent (of corresponding years). The correlation ratio between the two cycles is as high as 0·59 which according to accepted methods of statistics may be considered, as quite significant. By providing for one standard deviation of 18 per cent from corresponding years in the first cycle 67½ per cent of the years can be covered.

By providing for two Standard deviations, or 36 per cent on the average of flows, 95 per cent of the years can be covered, that is, with 36 percent of 346 or 120 × 1,000 m.c.ft. variation in the flow practically all the years can be covered; and 67½ per cent of the years can be covered with 60 × 1,000 m.c.ft. variation. It will be therefore possible to forecast, individual flow for a number of years within reasonable limits of variation.

On this basis, the forecast for 1956 is 323 × 1·27 × 1,000 m.c.ft. or 410 × 1,000 m.c.ft.

On a 67½ per cent probability, it will not vary by more than 18 per cent up or down or will be between 340 and 480.

The forecast for 1957 is 260 plus or minus 18 per cent, that is, 306 on 67½ per cent probability, even allowing two Standard deviations, it will not exceed 340 on 95 per cent probability. Hence 1957 will be a drought year.

For 1958, 1959 and 1960, the forecast is as under :—

Allowing one Standard deviation (18 per cent) 490, 560 and 700 (downwards).

Allowing two Standard deviations (36 per cent) 420, 450 and 530 (down-wards).

The figures indicate that on 95 per cent probability, 1959 and 1960 will be severe flood years and 1958 far above average. Thus it will be seen that using the periodicity or cycle-trends in river-flow the probable flow in any particular year

can be forecast. It may also be possible to forecast flows for particular lunar months or seasons on further study.

ADDITIONAL STORAGE CAPACITY.

In this connection, it will be of interest to note that the Mettur Reservoir provides only about 95,700 m.c.ft. storage at 120 feet (and t 126 feet 105,500 m.c.ft.) and its effective storage is less than one Standard deviation of 100 × 1,000 m.c.ft. Hence, it cannot even cover 67½ per cent of the years. Hence both for years of drought and floods, the present capacity will not be adequate.

On the other hand, if the capacity of the Mettur Reservoir is increased to about 125×1,000 m.c. ft. by raising the dam height, then on the basis of the study of the flow of the river during the last 40 years, it is seen that the capacity will be adequate to cover two Standard deviations of 18 per cent or 36 per cent of 340 × 1,000 m.c.ft. This will mean that the average flow can be ensured for nearly 95 per cent of the years in spite of the vagaries of the monsoons. Additional storage will safeguard against the floods, droughts and famines in the districts of Salem, Tiruchirappalli and Tanjore, and will ensure that the "Granary of the South" is adequately protected. It would appear that the original report of Mettur Project provided for increase of capacity and the foundations of the dam have also been designed for raising the same by another 10 feet, which will enable adequate increase in capacity of the reservoir.

It would also appear that a good storage of the order of 20–30 × 1,000 m.c.ft. can be provided above Hogenakkal falls in the Cauvery river, which will not only increase the total storage, but also provide for development of hydro-electric power and thereby increase the firm power as well as seasonal power at Mettur. This will solve both water shortage and power shortage in the State.

CONCLUSION.

It is a well-known fact that a few days' delay in letting down water at Mettur for irrigation, postpones the irrigation season, which results not only in the loss in yield in Kuruvai crop but also in late planting of Semba crop, which again results in loss of yield.

Further, due to lateness of planting, thare is damage of crops, due to rains, in the coastal areas during north-east monsoon. There is also improper and unbalanced use of available labour with the consequent loss of man-power at one time and shortage at the other time.

The provision of the additional storage of 20–30 × 1,000 m.c.ft. will not only help the commencement of irrigation season early by nearly three weeks, it will also provide for additional flow during the lean period in September or October, due to failure or delay in monsoons. Further, it will help to assure supply for about a month in December and January, if the north-east monsoon fails.

The provision of additional storage in the river Cauvery is an urgent necessity.

It is also suggested that similar studies of trends and cycles in the flow of other rivers in the Madras State like Vaigai, Periyar and Tambaraparani may be made for determining the flow at various

development sites. Such studies may be helpful in deciding the fesibility of augmentation of storage capacities; and installation or development of Hydro-Electric Schemes.

STATEMENT 1.

Statement showing the average mean and Standard Deviation for the first 13 *years of first cycle of* 27 *years beginning from* 1916 *and* 13 *years of subsequent cycle commencing from* 1943.

(a)			(b)			(c)		
Year.	*Inflow in* 1000 *M.C. Ft.* (x)	x^2	*Year.*	1000 *M.C. Ft.*	y^2 (y)			
						1929	323	1,04,329
1916	383	1,46,689	1943	459	2,10,681	1930	20–	41,616
1917	260	67,600	1944	292	85,264	1931	469	2,19,9[illegible]1
1918	171	29,241	1945	229	52,441	1932	535	2,86,225
1919	323	1,04,329	1946	484	2,34,256	1933	675	4,55,625
1920	247	61,009	1947	321	1,03,041	1934	265	70,225
1921	260	67,600	1948	391	1,52,281	1935	276	76,176
1922	252	63,504	1949	319	1,01,761	1936	321	1,03,041
1923	229	52,441	1950	366	1,35,424	1937	269	72,361
1924	302	91,204	1951	317	1,00,489	1938	287	82,369
1925	270	72,800	1952	277	76,729	1939	299	89,401
1926	283	80,089	1953	468	2,19,024	1940	427	1,82,329
1927	431	1,85,761	1954	446	2,00,704	1941	336	1,12,896
1928	318	1,01,124	1955	313	97,969	1942	347	1,20,449
	3,729	11,23,491		4,686	17,70,664		5,033	20,16,963

Average Mean (M_1) $= \frac{3729}{13} = 287$

Standard Deviation (S.D.) is root of $\left.\right\} \frac{1123491}{13}$

$= 2972$

S.D. $= 63{\cdot}66$

S.D. to M_1 = 22·3 per cent

Ratio of M2/M1

$M_2 = \frac{4686}{13} = 361$

S.D. = 76·72

S.D. to M2 = 21·25 per cent

= 1·27

Average Mean (M) for 27 years 1916 to 1942 $\left.\right\} \frac{8762}{27} = 325$

Standard Deviation (S.D.) $\left.\right\} = 103{\cdot}4$

Standard Deviation to (M) $\left.\right\} = 31{\cdot}8$ per cent

STATEMENT 2.

Statement showing the correlation (as a per cent) between the first 13 years of Cycle beginning from 1916 and the 13 years of subsequent cycle beginning from 1943.

Year.	A Inflow in 1,000 M.C. Ft. 'x'	B 'X' x 1·27.	Year.	C Inflow in 1,000 M.C. Ft.	D (C) to (B) in per cent.	E (D^2).
1916 ..	383	486·4	1943	459	94·5	9,025
1917 ..	260	330·2	1944	292	88·5	7,921
1918 ..	171	217·1	1945	229	105·5	11,236
1919 ..	323	410·2	1946	484	117·7	13,924
1920 ..	247	313·7	1947	321	102·2	10,404
1921 ..	260	330·2	1948	391	118·5	14,161
1922 ..	252	320·0	1949	319	99·7	10,000
1923 ..	229	290·8	1950	368	126·4	15,876
1924 ..	302	383·5	1951	317	82·6	6,889
1925 ..	270	342·9	1952	277	80·7	6,561
1926 ..	283	359·4	1953	468	130·4	16,900
1927 ..	431	547·4	1954	448	81·9	6,724
1928 ..	318	403·8	1955	313	77·5	6,084
					1306·21	1,35,705

Average Mean (M) of column 'D' $= \frac{1306{\cdot}21}{13}$

$= 100{\cdot}5$ per cent of Mean of Column 'B'

Standard Deviation is square root of $\left[\frac{135705}{13} - (100{\cdot}5)^2\right]$

$= 18{\cdot}4$ per cent.

STATEMENT 3.

Statement showing the Correlation—coefficient.

X	X^1 Difference over (M) of Y.	Y	Y^1 Difference over (M) of Y.	X^1Y^1	$(X_1Y_1)^2$
486·4	+ 122·1	459	+ 98·5	+ 12,020	144,480,400
330·2	− 33·1	292	− 68·5	+ 2,336	5,456,896
217·2	− 147·1	229	− 131·5	+ 19,340	374,035,600
410·2	+ 46·9	484	+ 123·5	+ 5,792	33,547,264
313·6	− 50·7	321	− 39·5	+ 2,003	4,012,009
330·2	− 34·1	391	+ 30·5	− 1,040	1,081,600
320·0	− 44·3	319	− 41·5	+ 1,840	3,385,600
290·8	− 73·5	368	+ 7·5	− 551	303,601
383·5	+ 19·2	317	− 43·5	− 835	697,225
342·9	− 21·4	277	− 83·5	+ 1,787	3,193,369
359·4	− 4·9	468	+ 107·5	− 527	278,029
547·4	+ 183·1	448	+ 87·5	+ 16,030	256,960,900
403·8	+ 39·5	313	− 47·5	− 1,876	3,519,376
4735·6		4686		+ 61,148	830,951,869

$M = \frac{4735}{13} = 364{\cdot}3$ $M = \frac{4686}{13} = 360{\cdot}5$ $M = \frac{61,148}{13} = 4,704$ $= \frac{830,951,869}{13} = 63,919,375$

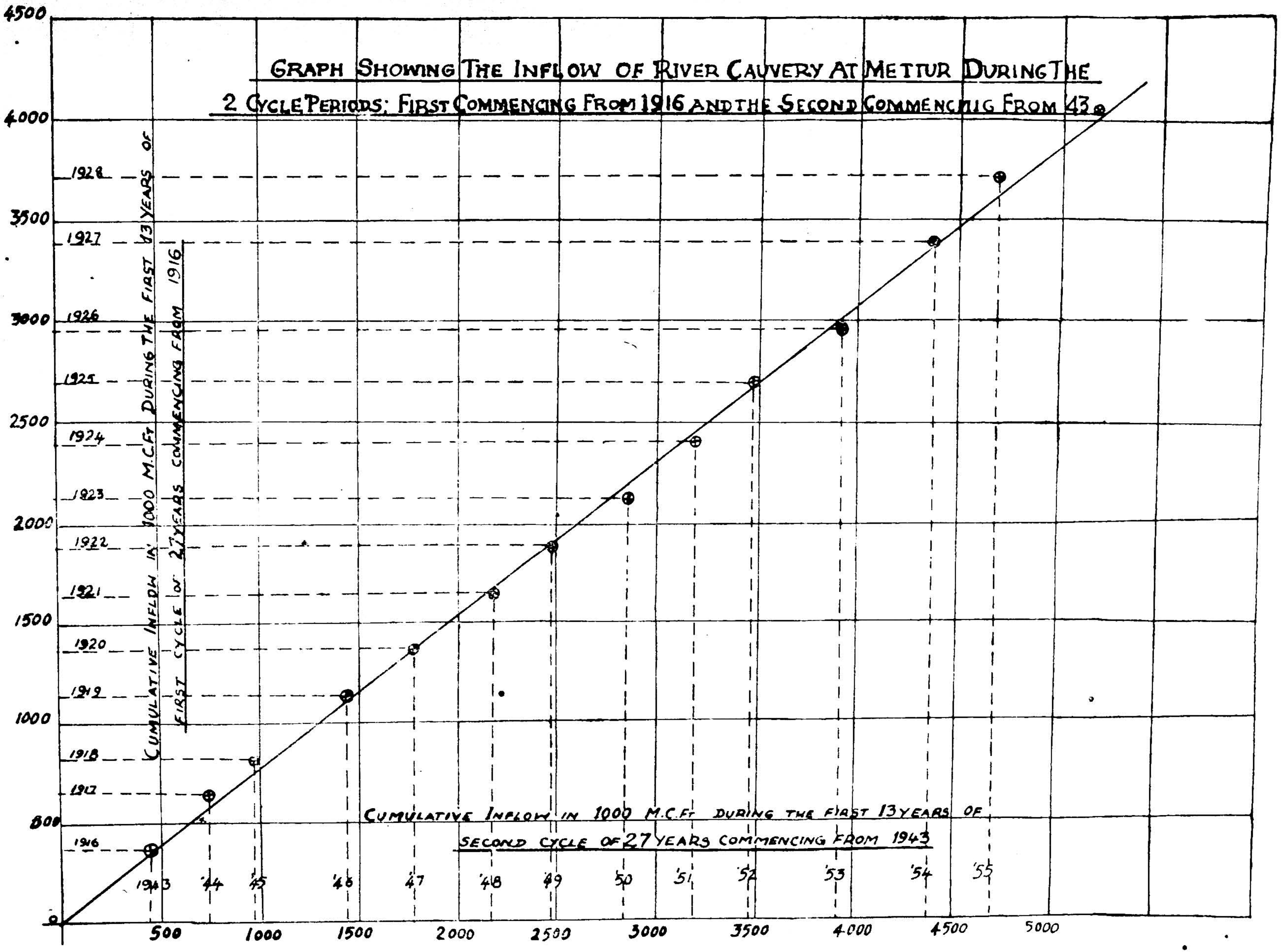
Square root of 63,919,375 $= 7,995$

Correlation cofficient $= \frac{4,704}{7,995} = 0{\cdot}588$

NOTE.—M = Average mean.

X represents the total annual inflow in 1,000 M.C·Ft. for each of the First 13 years of the First cycle commencing from 1916 multiplid by 1·27.

Y represents the total annual inflow in 1,000 M.C.Ft. for each of the years of the second cycle commencing from 1943.



GRAPH SHOWING THE INFLOW OF RIVER CAUVERY AT METTUR DURING THE 2 CYCLE PERIODS: FIRST COMMENCING FROM 1916 AND THE SECOND COMMENCING FROM 43
CUMULATIVE INFLOW IN 1000 M.C.FT DURING THE FIRST 13 YEARS OF FIRST CYCLE OF 27 YEARS COMMENCING FROM 1916
CUMULATIVE INFLOW IN 1000 M.C.FT DURING THE FIRST 13 YEARS OF SECOND CYCLE OF 27 YEARS COMMENCING FROM 1943
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1943
'44
'45
'46
'47
'48
'49
'50
'51
'52
'53
'54
'55
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

Tuberculation in Low Pressure Pipe Lines, Papanasam Project.

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THE AUTHOR.

THE ARTICLE BELOW gives an account of the tuberculation that was experienced in the low pressure pipe lines, at Papanasam, a study of the causes of its occurrence and the remedial measures taken to prevent its recurrence inside the pipe lines.

DESCRIPTION OF THE LOW PRESSURE PIPE LINE.

From the diversion weir on the Thambraparani River, two low pressure steel pipe lines of 9 feet diameter, lead the water to the power house. The low pressure pipe lines are about 3,550 feet in length and each terminates in a surge tower of the differential type, consisting of a 25 feet diameter steel outer tank with an internal riser of 9 feet diameter. Each surge tower is 47 feet high and has two outlets to feed through butterfly valves, 5 feet 6 inches diameter penstocks that carry the water 300 feet down the slope to the turbines.

The low pressure pipe lines are made of 3/8 inch Tatas steel plates, riveted and stiffened. The pipe lines are exposed (except at anchors) and are supported on flanged rollers mounted on rails. There are 8 anchors between the diversion weir and the surge tower. Below each anchor, there is an expansion joint in the pipe line. There are three 18 inch man-holes at anchors 1, 5 and 7 on the upstream side of the anchors.

There is an air-stand pipe of 24 inches diameter fixed on each low pressure pipe line on the down stream side of the diversion weir. These are made of ¼ inch plate.

The low pressure pipe line is 3/8 inch thick, with plate thickness of 7/16 inch at anchors and 5/8 inch at expansion joints. The required design thickness is ½ inch for the low head obtaining in this project (maximum static head is 55 feet). Allowing 1/16 inch for corrosion, the thickness needed is only 5/16 inch and with this thickness the factor of safety is about 4·4. Actually, the pipes installed are 3/8 inch thick, presumably because this is minimum standard thickness for rolled sheets.

The low pressure pipe line is designed for a flow of 750 cusecs and the water velocity is 11 feet per second.

No. 1 pipe line was completed in 1944 and No. 2 line in 1949.

2. INSPECTION OF PIPE LINE—FORMATION OF BLISTER GROWTH.

The inside of pipe line No. 1 was given two coats of 'Lustrol' aluminium paint over the shop coat of red-lead paint. Prior to putting the pipe line into service, flow of water of about 3 feet per second was being maintained in the pipe line for about 6 months to prevent buckling. The pipe line was inspected, when the test covers were removed for connecting it up at either ends and the examination revealed formation of quite a number of globules hanging from the plates; the aluminium paint was found peeled off from the under coat of red lead paint and hanging in semi circular patches. Tests on these globules at Alipore test house revealed that this was due to a certain kind of bacteria, and they suggested treatment with diluted sulphuric acid (one part of acid to 10 parts of water). Accordingly before commissioning the pipe line, the small pittings about 2 to 3 hundred in each shell varying from superfical scratch to hollows of 1/32 inch diameter and same depth, were cleaned and dilute sulphuric acid applied with showels. The surfaces were then washed with plentiful supply of water, and given 2 coats of red-lead paint.

Examination in subsequent years in 1945 and 1947, showed that the aluminium paint had been washed off more or less completly and the base coat remained. Formation of blisters was also observed.

Inspection in 1949 showed that the entire inside surface of the pipe line was coated with slush and grey colored organic matter, 1/8 inch thick, with blister-like formation or rust, covering nearly 1/3 the total inside surface of the pipe. When some of the blisters were removed, the bright metal surface of the pipe was exposed and small depressions of about 1/16 inch depth were noticed due to the metal, having been eaten up at the places, where the blisters had been formed. At the places affected by the blisters, there was no trace of any paint but in the surface surrounding the blistered area the paint was intact.

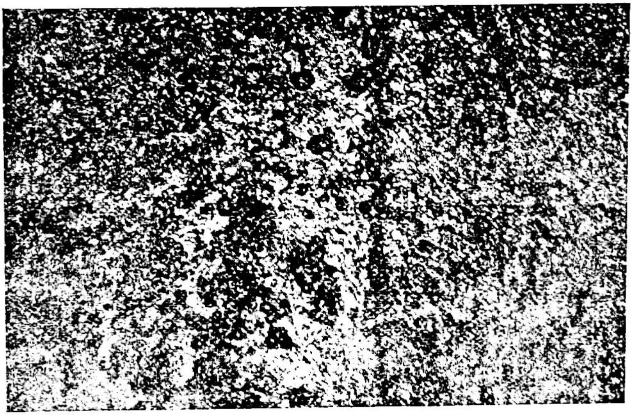
The extent of wear had increased from 1/32 inch to 1/16 inch in the course of two years and the damage was appreciable.

Examination in the years 1953 and 1955 showed that 95 per cent of the inside surface was covered up with these blisters. It was further noted on opening the man-hole cover for inspection in 1954, that plenty of flying insects were emerging out of the pipe line.

The photo opposite gives an idea of the appearance of the inside of the pipe line during one of these inspections.

3. INVESTIGATION INTO THE CAUSES OF TUBERCULATION AND CORROSION.

The formation of these blisters was engaging the attention of the Department right from the start and the problem was referred to reputed firms like Imperial Chemical Industries, for advice in the cause of their formation and suggestions for their prevention. The King Institute, Guindy, took a keen interest in the



Ins'de surface of Pap na am pipe lino showing blister formation.

matter and studied the problem through site investigation, analysis of water samples, the blisters and the insects found in the man-holes. From a study of the analytical data, collected during their survey, they found that the waters of the Thambraparni reservoir and the diversion weir would cause corrosion of unprotected iron structures in contact with the water, for the reason that these waters contain high amounts of oxygen and free carbon dioxide in solution, besides being soft, and neutral to acid in reaction. These waters also contain bacterial organisms belonging to the chlamyclobacterias, which are commonly known as iron bacteria besides many slime forming sulphate reducing algal organisms. These bacteria assimilate iron from the water and eliminate it in the form of soluble ferrous hydroxide. The ferrous hydroxide is oxidized to insoluble ferric hydroxide by dissolved oxygen in the water, and may deposit in the form of tubercles on the inner surface of the pipe. Corrosion may then result from the establishment of differential oxygen concentration cells carri d by the exhaustion or exclusion of oxygen from the centre portion of the tubercles. The iron sulfide found in the tubercles indicate that anærobic sulphate-reducing bacteria are also present and that corr sion is probably due to the joint action of the two types of bacteria.

Insects found on the pipe lines have been identified to be caddis flies. These insects are terrestrial in habit and are found near ponds, streams and lakes. They are short lived. In the case of Papanasam

pipe lines, the eggs probably gain access into the pipe line and into the tubercles along with the organic debris carried by the water. Subsequently they hatch and the larvæ come out. These larvæ thrive well under the oxygen supplied by the water and live on the organic matter and planktonic algal organisms contained in the water and tubercles. After an active larvæ stage, they enter the resting pupal stage, which lasts for about two weeks and then molt into the adult insects. As the pipes are normally flowing full, it is likely the insects will appear dead in the tail race water. The swarm of insects found at the time of opening of man-hole, are presumably those, which have come out after molting, on the pipe line being emptied.

Results of analysis of Lake water samples and the tubercles collected from drain discharge pipe by the King Institute are given in Appendix I.

4. METHODS OF PREVENTION OF TUBERCULATION.

Tuberculation may be prevented by rendering the water non-corrosive by suitable chemical treatment. This can be achived readily by dosing the water with sufficient lime to destroy all the free carbon dioxide and raise the P.H. value to about 8. Such methods are obviously uneconomical and impracticable in the present instance, when dealing with large volumes of water carried by the pipe lines. Protection of the pipe surface by suitable surface coating is therefore the only economical means of preventing tuberculation and its undesirable effects, on the material and the carrying capacity of the pipe lines.

5. EXPERIMENTS ON VARIOUS TYPES OF PAINT:

The King Institute recommended trial of coal tar enamels and bitumastic paints. With a view to study the effectiveness of the various types of paint, sample plates, with the paints coated, were kept immersed in the intake chamber of the diversion weir and periodical observations made. The results of trial of various paints are given in Appendix II. As a result of such trials, it was found that coal tar gives good protection to the metal surfaces, as also a base coat of red-lead and super coat of black inertol. It is interesting to observe that the Beaureau of Reclamation, U.S.A., has been using *coal tar enamel* coating for their penstocks, as this has been found to minimize or eliminate tuberculation and corrosion caused by the activity of the iron and sulphate-reducing bacteria.

A description of coal tar enamel and coal tar paints may not be out of place here and is given below :—

Coal tar pitch is converted to coal tar enamel by incorporation of mineral filler. The development of coal tar enamel represented a large step forward in coal tar protective coatings. While retaining the impervious properties of the common pitch, it acquired less susceptibility and greater stability to temparature extremes, both hot and cold and greater stability in flowing water. It has its limitations. It is critical in its applications, requiring utmost care in all operations from cleaning of the metal surface to the application of hot enamel. Coal tar paints are made by liquifying coal tar pitch by heating and then combining it with a solvent. The solvent must

be a coal tar distillation product, such as xylol or coal tar naphtha to insure homogeneity of the paint.

Although coal tar paints possess a distinct advantage for surface coats, because they may be applied at ordinary temperatures by brush or spray, cold applied coal tar paints are not usually recommended, where hot applied pitch or enamel coatings are feasible.

6. PAINTING OF LOW PRESSURE PIPE LINE No. 1.

In view of the large incrustations in the pipe line, the frictional loss of head became very high and it became necessary to restrict the loading on the pipe line to 12,000 KW. (600 cusecs) as against its normal capacity of 14,000 KW. (700 cusecs). With the diversion weir level at 637 feet. and with a load of 13,000 KW. the water level at the surge shaft was only 610 feet — 1½ feet below the part holes—that is loss of head of 27 feet. The removal of the incrustations and repainting became therefore imminent and was taken up from 9th April to 6th May 1956. The entire pipe line was scraped and a section of the pipe line was given two coats of coal tar, and some portions with a base coat of red lead and super-coat of inertol black. The difficulty about application of coal tar is that it takes long to dry and drips with the pipe line empty and exposed to the sun's heat. A short stretch of the pipe line was treated first with phosphatizert before the paints were applied for purpose of observation of the effecs of phosphatising.

As a result of this scraping and repainting, there has been cosiderable improvement in the frictional head loss. With a load of 14,000 KW., the loss of head after cleaning and repainting is only 16 to 17 ft., which agrees with the calculated loss of head for a flow of 700 cusecs under normal conditions.

7. CONCLUSION.

The tuberculation and corrosion in the pipe line have been caused by the characteristics of water in Thambraparni river. The necessity for periodical cleaning and painting with coal tar base paints is indicated, as otherwise not only would the pipe deteriorate, but the loss of head due to incrustation would limit the capacity of the pipe line.

APPENDIX I.

PAPANASAM HYDRO-ELECTRIC PROJECT.

Results of fiel l tests on Hope Lake water—March 1956—

Temperature of water	..	29·0° C
Free CO_2 (ppht)	..	0·15
Nitrites, ferric iron and ferrous iron.	..	Nil.
Alkalinity	pp.	Nil.
(ppht)	Mo.	0·9
PH	..	7·0
Corrosivity test:	PH.	8·4
x_s Alkalinity	pp.	0·4
(ppht)	Mo.	3·4
Dissolved O_2	ppm.	7·4

Results of microscopical and bacteriological examination — Iron bacteriadiatoms desmids, rotifers, crest-acilans.

Results of chemical analysis of tubercles—

	PER CENT.
Total ferrous iron as FeO	6·93
Total ferric iron as Fe_2O_3	73·6
Insoluble in HCl	7·2
Total sulphides as FeS	0·004
Loss on ignition	12·9

APPENDIX II.

Statement of sample paints under test—Report of inspection by Superintending Engineer (Generation), Erode, on 1st *March* 1956.

Serial number.	*Name of paint— (a) Inner coat. (b) Outer coat.*	*Date of painting.*	*Observation of the condition of the plate on removal *.*
(1)	(2)	(3)	(4)
1	(a) "Inertol" Standard Black Anticorrosive—Chanda and Company, Calcutta.	20 Dec. 1953 ..	Good condition.
	(b) Do.	28 Dec. 1953 ..	Do.

* All the plates were immersed 4½ feet deep under water for the tests.

Serial number.	*Name of paint— (a) Inner coat. (b) Outer coat.*	*Date of painting.*	*Observation of the condition of the plate on removal.*
(1)	(2)	(3)	(4)
2	(a) "Inertol" Standard Black Anti-corrosive—Chanda and Company, Calcutta.	20 Dec. 1953 ..	Three pittings on one side bottom edge—few incrustations on opposite side; condition—fairly good.
	(b) Do.	28 Dec. 1953 ..	
3	(a) Coal tar	18 Dec. 1953 ..	Fairly good; some patches of incrustations on one side scattered all over the full width of the plate: rest of the area on same side in fairly good condition. Opposite side two encrustations—the rest of the plate fairly good condition.
	(b) Do.	28 Dec. 1953 ..	
4	(a) Do.	18 Dec. 1953 ..	On one side one patch encrustation; rest of plate fairly good; much of the painting washed off.
	(b) Do.	28 Dec. 1953 ..	
5	(a) Do.	18 Dec. 1953 ..	Both surfaces having incrustation; condition bad.
	(b) Do.	28 Dec. 1953 ..	
6	(a) Do.	18 Dec. 1953 ..	One side in good condition; other side paint washed off in certain sections and slight encrustation beginning.
	(b) Do.	26 Apr. 1955 ..	
7	(a) Do.	20 Apr. 1955 ..	Condition good. One incrustation formed in middle of bottom edge of one side.
	(b) Do.	26 Apr. 1955 ..	
8	(a) Red lead	16 Nov. 1954 ..	One side good; other side paint washed off apparently due to hitting against another plate.
	(b) 1. Red lead .. .. 2. Inertol	24 Nov. 1954 .. 3 Dec. 1954 ..	
9	(a) Red lead	16 Nov. 1954 ..	Good condition; bubbles formed on Cordoplast paint layer, at few places; hardly any incrustations.
	(b) 1. Red lead .. .. 2. Cardoplast ..	24 Nov. 1954 .. 3 Dec. 1954 ..	
10	(a) Red lead	16 Nov. 1954 ..	Same as the previous item but bubbles are more prominent and uneven; a few bubbles have burst and condition of exposed metal is good.
	(b) 1. Red lead .. .. 2. Coal tar	24 Nov. 1954 .. 3 Dec. 1954 ..	

Serial number.	*Name of paint— (a) Inner Coat. (b) Outter Coat.*	*Date of painting.*	*Observation of the condition of the plate on removal.*
(1)	(2)	(3)	(4)
11	(*a*) Red le d .. .. (*b*) 1 Red lead .. .. 2 Red lead	16th Nov. 1954 24th Nov. 1954 3rd Dec. 1954	Paint washed off in patches. A few small incrustations found on both sides of the plate, where paint is washed off, possibly due to touching adjacent test piece; rest of the portions good.
12	(*a*) Red lead .. .. (*b*) Black Apexior No. 3, British paint.	20th Apr. 1955 26th Apr. 1955	One incrustation formed on middle, third of one edge. Other side incrustation formed on the upper edge.
13	(*a*) Red lead .. .. (*b*) Black Apexior No. 3, British paint.	20th Apr. 1955 26th Apr. 1955	Fairly good condition. A few bubbles formed on one side. Paint removed in certain patches.
14	(*a*) Red lead .. .. (*b*) Black-Barico Anti-corrosive J & N.	20th Apr. 1955 26th Apr. 1955	General condition good. Number of bubbles formed on both sides. No incrustations, paint washed of slightly but condition is good.
15	(*a*) Red lead .. .. (*b*) Black-Barico Anti-corrosive J & N.	20th Apr. 1955 26th Apr. 1955	General condition good. Number of bubbles formed on both sides. No incrustations. Paint washed of slightly but condition is good.
16	(*a*) Y- C. Primer .. (*b*) Black Apexior No. 3, British paint.	20th Apr. 1955 26th Apr. 1955	One side general condition good: on other side paint removed in a patch, where small incrustations have started forming. Condition good.
17	(*a*) Y. C. Primer .. (*b*) Black Apexior No. 3, British paint.	20th Apr. 1955 26th Apr. 1955	General condition good. Paint removed in places. A few small incrustations started in area where the paint is removed.
18	(*a*) L. C. 8 Primer .. (*b*) Black anti-corrosive J & N.	20th Apr. 1955 26th Apr. 1955	One side Barico paint completely washed off. Other side both the paints removed in a small area, and incrustations formed therein. General condition good.
19	(*a*) L. C. 8 Primer .. (*b*) Black anti-corrosive, J & N.	20th Apr. 1955 26th Apr. 1955	General condition good. One side Barico paint completely washed off. Other side both the paints removed in a small area and incrustations formed therein.
20	(*a*) Shellac varnish .. (*b*) Shellac varnish ..	20th Apr. 1955 26th Apr. 1955	Condition bad.
21	Copperised M.S. plate; 5, 6, 7 and 8, Mts. Immersion time.	29th Oct. 1955	Covered with deposit. Further study required.
22	M. S. plate without any paint.	29th Oct. 1955	Full of incrustation.
23	Gunnited M.S. Plate.	5th Dec. 1955	Good condition.

Electrical Accidents in the State.

By the EDITOR.

THE EDITOR.

THE FOLLOWING IS A REVIEW of electrical accidents in the State during the five year period 1951–56.

There were 1,269 electrical accidents during the period 1951–56 in this State, out of which 964 occurred in the Government Electricity Department areas, and 305 in the areas covered by Electric Supply Companies, Local Authority Undertakings and non-licensees like H.T. consumers, etc. Out of the 964, accidents in the Government Electricity Department area, 339 proved fatal : and out of the 305 accidents in the remaining areas, 94 proved fatal.

The classified list of the electrical accidents both fatal non-fatal, in the Departmental area and the rest of the areas in the State are given below for the 5-year period from 1951–52 to 1955–56 :—

	Fatal accidents.			*Non-fatal accidents.*		
Year.	*Government Electricity Department.*	*Licensees and non-licensees.*	*Total.*	*Government Electricity Department.*	*Licensees and non-licensees.*	*Total.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1951–52	78	13	91	121	47	168
1952–53	66	20	86	153	46	198
1953–54	57	19	76	99	48	147
1954–55	44	18	62	109	22	311
1955–56	94	24	118	144	48	192
Total fatal..	339	94	433	625	211	836
Total non-fatal.	625	211	836			
Grand total.	964	305	1,269	..	..	..

The largest number of accidents has occurred during the year 1955–56, namely, 310. Out of these 238 pertained to Government Electricity Department area, and 72 to other areas. In 1955–56, the maximum number of fatal accidents has also occurred, namely, 94, in the Departmental area and 24 in the rest, totalling 118. The maximum

number of non-fatal accidents, namely, 152, occurred in 1952–53, in the Departmental area, whereas the maximum number of non-fatal accidents in the other areas, namely, 48, occurred twice, once during 1953–54 and again in 1955–56.

The strikingly large number of fatal electrical accidents, which have taken a toll of 433 lives in the whole State during the period 1951–56, indicates that an effective control of accidents, is possible only if special and new methods are devised and employed for construction, operation, and maintenance; and educating the staff and the public and also the existing methods are modified, on the basis of past experience, to suit typical field conditions, keeping in view the variations, that may occur from place to place.

From a review made by Chief Engineer for Electricity of the fatal and non-fatal accidents that occurred during the last 5 years, it is revealed that many of the accidents could be attributed to the want of efficient supervision by the supervisory staff as also to the particularly low standard of work on the part of a few members of the field staff. Typical instances of accidents, which, it is believed, were mostly due to want of supervision on the part of construction and maintenance staff of the Department are enumerated below :—

(1) In one case, after the modification to a distribution line, involving fresh jumpering at two places, a wrong jumpering had been made interchanging phase and neutral. This interchange made the neutral live, and a lady, who came in contact with the connected stay, was electrocuted.

The accident could have been avoided by proper supervision of the line staff.

(2) In another case, the bolts and nuts of a shackle on the cross arm of a distribution line had been improperly tightened, with the result, the bolt gave way: and the shackle and conductor fell down forcibly disconnecting, a nearby service line from the phase wire and plunging the premises into darkness. A boy, who came in the darkness, contacted the live wire and received an electric shock.

If the shackles had been carefully tightened, the accident would never have occurred.

(3) One accident was caused by the inadequate clearance of distribution line from a building.

As buildings may come up after laying of lines in many places, it is the responsibility of not only the construction but also of the operation and maintenance staff to be watchful and to ensure that the minimum clearances laid down in Indian Electricity Rules are always maintained.

(4) There was a case of fatal mechanical accident, that occurred to a departmental worker, while unloading R.C.C. poles from a lorry. It was understood that the unloading was supervised by the driver of the lorry only.

The accident could have been avoided if handling of heavy materials is done, as a rule, under good supervision. Proper serangs should be employed, whenever

heavy materials, equipments or machinery are handled, and loading and unloading should be done with all precautions taken, and utmost care exercised to ensure safety.

(5) Some accidents have occurred due to people coming in contact with snapped conductors of O.H. lines remaining live, and lying across streets. Some cases of conductor snapping could be attributed to defective paving out and over-tensioning of conductors.

Accidents of this kind can be avoided by having great care exercised in the erection of main and distribution lines and through proper supervision. Rule 91 (1) of Indian Electricity Rules, 1956, has to be complied with and provision for effective earthing of any snapped conductor and rendering it dead should be available. In practice compliance with this rule in the case of all O.H. lines will be prohibitively costly. It has been, however, found possible for the provision of devices for earthing a snapped conductor in the case of L.T. and medium voltage lines at locations where lines cross main trunk road and streets, subjected to heavy traffic. Such provisions serve to eliminate accidents at busy localities or vulnerable points on the line as far as economically possible.

(6) Certain accidents can be traced to the lack of proper co-ordination of work between gangs. To cite an example a line clear was lifted by one gang, even when the other gang was still working on the line-a clear case of uncordinated supervision.

To avoid accidents due to this cause, the line clear form in vogue in the Department has been revised recently, incorporating certain additional clauses, that would go a long way in correcting the deficiency.

(7) Many accidents have occurred at consumers, premises due to inadequate and infrequent inspection by the supervisory staff of the services in their area, check up of the conditions of the installations and service equipments, bringing the defects to the notice of the consumers and demanding rectification thereof.

In this connection, it has to be hailed as an event of great importance that two new Indian Electricity Rules have been brought into effect, in the State during 1956, namely, rule 45 and rule 46. As per rule 45, electrical installation works in the consumers promises, which have been carried out by a person not holding an electrical contractor's licence and under the direct supervision of a person, not holding a certificate of competency, issued by the State Government, shall not be connected to the supply mains. A Licensing Board has been constituted for the issue of licences and certificates of competency to electrical contractors, and electrical supervisors and wiremen, respectively. The field officers are empowered to refuse, and should refuse to effect supply to electrical installation works carried out in contravention of Rule 45 (1) of Indian Electricity Rules, 1956. While this rule takes care of the installations at the commencement of supply, rule 46 ensures that its standard is maintained thereafter by stipulating that all electrical installations shall be periodically inspected and tested at intervals not exceeding five years. The period of five years

can be considered to be a safe limit for the frequency of such tests as a good work with good materials executed by lisensed contractors under direct supervision of qualified personnel as per Rule 45 may definitely be expected to stand the strain of this period. By proper but rigorous enforcement of Indian Electrical Rules 45 and 46, accidents in the consumers' premises can be reduced considerably. It is, therefore, for the suppliers to rise up to the occasion and co-operate with the electrical inspectorate to make a rigorous enforcement of these rules without any relaxation what-so-ever.

One common cause of accidents appears to be inquisitive climbing of cow boys and country folk on poles and coming into contact with the live wires, ignorant of the dangers involved therein. To prevent such un-authorized climbing, Indian Electricity Rule 91 (3) stipulates that anti-climbing devices should be provided on all poles, carrying H.T. power lines : providing such devices, on all line supports should be prohibitively costly and the best solution, to avoid such accidents, probably lies in educating the rural public regarding dangers involved in tampering with live lines. A few measures that could well be adopted for efficient publicity among the villagers and to impress on them the dangers involved in climbing up the poles, carrying power lines, are given below :—

(i) Caution boards, both in English and Tamil, can be provided with some pictorial representation, indicating danger, on all towers and important pole locations.

(ii) Special broadcasts may be included in rural service programmes of All-India Radio, explaining the dangers involved in tampering with electricity.

(iii) The village school masters may be advised to instruct their pupils of the dangers of electricity and train them to be careful in handling electrical apparatus.

(iv) Mobile propaganda units can be organized to tour the villages and caution the villagers through loud-speakers, by conducting meetings and showing documentaries on the subject, particularly when a line is newly energised.

(v) Advantage can be taken of the popularity of the cinemas with the public both in the villages and towns. Arrangements can be made for projecting slides, as well as short reels, being shown periodically prior to the commencement of regular shows, similar to the information reels. Such projection can be made compulsory by arrangement with the Government of India and there can be no doubt, that the public would be greatly benefitted thereby.

It has also to be emphasised that all general safety precautions in attending to maintenance and construction works have to be correctly observed. There have been accidents, while attending to fuse-off calls at service connections, by receiving electric shocks and falling down from pole-tops. Use of rubber gloves and safety belts would have averted these accidents. Observance of basic safety regulations would help to avoid such and similar accidents. For constant reference by the field-staff, a safety manual, incorporating safety rules to be observed, and instructions to be followed, by men engaged in

construction, operation and maintenance works, is being compiled in the office of Superintending Engineer, Technical (Electrical). It is desirable, that the safety code, as soon as at it is finalised, is printed both in English and in local languages, and is made available for sale at a cheap rate, so that the information reaches maximum number of persons in quick time. It is felt that a vigorous "safety first" drive in essential to give beneficial results.

With the present high tempo of development in our Department, inefficient supervision, and carelessness to observe regulations and instructions issued from time to time, if allowed to continue, will in coming years, lead to a large increase in the rate of electrical accidents. It is therefore necessary that all such cases are severely dealt with and deterrent punishment awarded to the offenders.

Wide circulation among the Departmental Staff of instructions, with respect to the observance of safety rules, and relevant Indian Electricity Rules, in all their activities, would go a long way in preventing electrical accidents.

Central Co-ordination in Power Development.*

By Sri S. RAMAN, B.E. (Hons.),
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Early History.

WITH THE ONLY EXCEPTION of Mysore State, where generation and distribution of electric supply were carried out by Government, the early electrical installations throughout India were initiated and run by private enterprise. In the beginning, electric supply was largely confined to big cities like Calcutta, Bombay, Madras and a few important towns. The centre took no hand either in electric power development or in the assessment of hydro electric possibilities of the country, and only passed legislation to regulate the generation, distribution and sale of electrical energy, and to ensure observance of adequate safety precautions. During World War I, however, the Industrial Commission appointed by Government recommended an immediate and systematic hydrographic survey by Government.

* Compiled from an article on "The role of the Ministry of Irrigation and Power in Power Development" by Sri Sivasankar, in Power Engineer, April 1956.

The recommendation was accepted, and three reports were brought out by 1922, embodying information regarding the possibilities of power generation in various areas in the country. Unfortunately, the introduction of Montford Reforms, at this time, excluded 'electricity' from the purview of the Centre and made it a 'Provincial' subject. The Provinces were not interested in continuing a survey, that held out no immediate prospects and the Centre could not constitutionally finance it. The work, inherently of highest importance for the development of the country, had to be discontinued. The position was later corrected in the Government of India Act, 1935, that made electricity a 'concurrent' subject, but curiously enough nothing much was done till the second world war, when the need to ensure an adequate power supply to ordnance factories and other industrial units, engaged in war effort, made the centre, once again to interest itself in electric supply industry, and electrical development.

Organisation till 1952.

In pursuance of the Roger Mission's recommendations, an electrical commissioner was appointed by Government in 1941, to ensure power supply for the production of munitions and essential services engaged in war effort. The functions of the electrical commissioner, on termination of war, were extended from time to time, to meet piece-time requirements until they comprehended, in their scope, such matters, as the drafting of electricity legislation, service of power requirements in coal-fields, advising the Central Government in the formulation of a National Electricity Policy, and the Provincial Governments in the administration and control of electrical licensees, and a host of other functions, including a systematic collection, for the first time, of data regarding the production and distribution of electricity in the country, as a whole.

Another important step was taken in 1944, when in accordance with the resolution passed by the technical conference on Post-War Electric Power Development, which was accepted by the Reconstruction Committee of the Council. Government set up a Central Technical Power Board, charged with the general responsibility for "initiating, co-ordinating and formulating schemes of power development and utilisation throughout the country in consultation with the Provincial and State Governments concerned". The Power Board was intended to function as a development organisation in consultation and contact with various authorities like the Central Government Departments, State Government, as well as Boards and Commercial Organisations; and its functions, as set out in the resolution constituting it, were chiefly as follows :—

(*a*) to survey the electric power requirements of any region;

(*b*) to prepare project reports with a view to encourage the appropriate authority to implement the scheme;

(*c*) to formulate schemes for the wide spread utilisation of electric power:

(*d*) to maintain contact with all Provincial or State Governments and to render advice for development, in their regions;

(*e*) to encourage irrigation and agricultural authorities, to develop irrigation and rural electrification; and

(*f*) to be responsible for hydrographic surveys throughout India.

The Board was required to lay down for the whole of India standard voltages and practices for generation, transmission and distribution of electricity, and to initiate research on requirements suited to the special conditions in India. The Central Electrical Commissioner however continued to deal with "post-war problems in connection with the procurement of heavy plant from overseas, and to maintain statistical data relating to electrical generation, supply and distribution.

One notable achievement of the Power Board was the planning and formulation of the Damodar Valley Project, after a comprehensive study of the related problems in 1945, as a unified scheme of development for the valley as a whole, on the T.V.A. pattern.

The existence of two separate agencies dealing with the same subject was by no means a satisfactory arrangement, and the position was further complicated by the emergence in 1945 of a third organisation called the Central Water Power, Navigation, and Irrigation Commission charged with the responsibility of handling all questions pertaining to hydro-electricity. The Government, therefore, reviewed the position in January 1948, and decided that the duties performed by the Electrical Commissioner and by the Central Technical Power Board, with the exception of hydro-electric power generation, should be performed by a new organization styled the Central Electricity Commission.

In 1951 on grounds of economy and efficiency, the Central Electricity Commission and the Central Water Power, Irrigation, and Navigation Commission were amalgamated into one organisation known as the Central Water & Power Commission. The Commission was charged among other things with the "general responsibility of initiating, co-ordinating and furthering schemes for the conservation and utilisation of hydro resources throughout the country, for purposes of flood control, irrigation, navigation and power generation, as well as schemes of thermal development.

The subject of electricity was dealt with by the Department of Labour in the Government of India till 1946, when it was transferred to the newly created Department of Works, Mines and Power. Subsequently, all subjects pertaining to natural resources, including water and electricity development, were transferred to the Ministry of Natural Resources and Scientific Research, constituted in 1951.

In 1952, befitting the importance given to irrigation and power projects in the First Five-Year Plan, the Government constituted a new Ministry called the "Ministry of Irrigation and Power" and transferred the subjects relating to water and power development to it.

Working of the Ministry of Irrigation and Power.

GENERAL FUNCTIONS.

Electricity is a "concurrent" subject under our Constitution, unlike irrigation, which is a State subject. The Ministry of Irrigation and Power is therefore in a good position to exercise direct control and supervision over the production and distribution of electricity. Want of relevant data regarding the water power resources of the country, due to the discontinuance of the hydrological survey, made it difficult to formulate dependable schemes. The Ministry had therefore to initiate measures for the collection of basic information regarding the irrigation and hydro-electric potential of our various river basins in conjunction with the States, in a systematic manner. Besides, during the progress of the First Five-Year Plan, the need for a comprehensive load survey of the entire country had been increasingly felt for the proper co-ordination of large power development projects in the Second Five-Year Plan. With this in view the Ministry had authorized the Central Water and Power Commission to undertake such load survey in co-operation with the States and a good amount of work has already been done on this.

STATE PLANS.

On the dawn of independence, many State Governments came out with ambitious plans for power development, in their areas, for which the centre was requested to provide necessary finances; and these had to be co-ordinated and priorities fixed, to enable uniform progress being made all over the country. The Ministry has had therefore, to modify and phase the different programmes of power developments and to extend financial assistance to them.

PLANNING COMMISSION.

The planning commission was set up in 1950 to co-ordinate the efforts of the various units in the preparation of properly integrated programmes of development. Necessary assistance is given by the Ministry to commission in the examination and co-ordination of electric power projects, all over the country.

The technical aspects of electricity schemes are examined by the Power Wing of the Central Water and Power Commission. The central commission also examined the financial aspects of the schemes, the requirements of power in the whole region, and also the feasibility of co-ordination of each scheme with similar schemes in the area. After detailed examination, the schemes are placed before a technical committee appointed by the Planning commission. The committee is presided over by the Deputy Minister of Irrigation and Power: and the Chairman and Members of the Central Water and Power Commission are among its members.

The technical committee scrutinises the projects on the particular aspects of proper investigation, accuracy of estimates, correctness of financial forecast, and revenue return.

At the stage of the finalisation of the irrigation and power schemes for inclusion in the Plan, the Planning Commission held discussions with the State Governments under close association of the Ministry. The Power Plans of different States were

considered by "working groups" initially, and final decisions were arrived at after thorough and detailed discussion.

The allotment for power projects in the Second Five-Year Plan will be Rs. 413 crores against Rs. 266 crores in the First Plan. The benefits anticipated during the Second Five-Year Plan period will be the addition of about 2·9 million kW of installed generating capacity, in the public sector.

PROGRESS OF CENTRAL PROJECTS.

The Ministry has the responsibility to watch the progress of projects receiving financial assistance from the centre. In this category fall three major multi-purpose river valley projects, Bhakra, Hirakud and the Damodar valley, which had been started before the commencement of the First Plan; and certain other major projects like the Rihand, Koyna, Chambal and the Nagarjunasagar, included in and started during the First Plan.

One Control Board consisting of the representatives of the participating States and the Centre has been set up by the Ministry for the execution of the Bhakra Nangal Project and a similar Board for the Hirakud Dam Project. The Governor of Punjab in his personal capacity is the Chairman of the former, and the Secretary to the Ministry is the Vice-Chairman. The Chairman, Central Water and Power Commission, and a Joint Secretary in the Ministry of Finance are among its members. The Chief Minister of Orissa is the Chairman of the latter. The Secretary to the Ministry is its Vice-Chairman and a joint Secretary of the Finance Ministry is a member.

The Damodar Valley Project has been put in charge of the "Damodar Valley Corporation" which is an autonomous body, charged with the promotion, execution and operation of the entire scheme including transmission and distribution of electrical energy, both hydro-electric and thermal.

EXPANSION OF FUNCTIONS.

The Central Water and Power Commission looks after all investigations, surveys and preparation of river valley schemes, advises Government with respect to electricity legislation and settlement of priorities for plants and foreign exchange; collects statistical information regarding generation and utilisation of electricity, conducts research on various aspects of river valley development, standardises plants and machinery, and does a host of other functions, including the mighty proposal of preparing a "master plan of rural electrification" for the entire country to be implemented over a period of twenty years.

LEGISLATIVE MATTERS.

The Indian Electricity Rules dealing with the general procedure for the grant of electric licences, and conditions of power supply were modified last year and new rules now apply to the whole country.

Amendments of the Indian Electricity Act, 1910, to suit present day needs is under active consideration of the Ministry.

CENTRAL ELECTRICITY AUTHORITY.

With a view to promote co-ordinated power development in the country, the then Ministry of Works, Mines and Power had passed in 1948, the Electricity Supply Bill, which provides for the establishment

of regional organisations called the State Electricity Boards, and a Central Organisation called the Central Electricity Authority. The State Electricity Boards are semi-autonomous bodies charged with the duty to control electric power development of the area, in their jurisdiction, and regulate its growth into a rationalised and co-ordinated system, in which generation would be concentrated in power stations, suitably located and transmission effected to the load centres through high-tension power grids.

The Central Electricity Authority endeavours to develop a sound and uniform national power policy in co-ordination with the activities of planning agencies in relation to the available national power resources and promotes formation of regional and interstate grids with a view to have a national grid covering the entire country.

The Central Electricity Authority now consists of four members. The Secretary to the Ministry of Irrigation and Power is its Chairman. Both the Members of the Central Water and Power Commission in the Power Wing are the members of the Authority; and they are empowered to act, whenever necessary, on behalf of the Authority. The Secretariat of the Authority is provided by the Central Water and Power Commission and its Secretary is a senior officer in the Power Wing of the Central Water and Power Commission.

The Government of India does not impose any restrictions on the growth of electric supply industry in private sector; but has left it to be regulated by the Electric Supply Act, 1948. However, while the generating capacity in the Public Sector has been rapidly expanding, the scope of the, Private undertakings is limited to the maintenance of power supply in the existing licensed areas. Disputes between the licensees and the States or differences, as to interpretation of rules, can be referred, by either of the parties, for arbitration to the Central Electricity Authority.

FOREIGN AID.

The Ministry has been making available, foreign, financial and technical assistance for power development in the country. Under the various aid programmes, viz., the United Nations Technical Assistance Scheme, the United States Foreign Operations Administration, and the Colombo Plan, the Ministry obtained financial assistance for the purchase of plant and equipment, and the services of foreign experts for the construction of power projects. Indian engineers are also being trained abroad on foreign fellowships under these schemes.

CONCLUSION.

Electric power development transcends state frontiers and is truly a national subject. Left entirely to the states, the development is apt to be haphazard and ultimately lead to inefficiency and waste. The Ministry of Irrigation and Power seeks to co-ordinate the activities of the various States and direct them along lines, which merge into the general pattern of a comprehensive national development programme, of which the electric power development is an important and basic component. The Central Water and Power Commission, the Planning Commission, the Central Electricity Authority, and associated bodies and organisations assist the Ministry of Irrigation and Power in this huge task of "All-India Planning and Development."

Speech of Shri Gulzarilal Nanda at Power Engineers' Conference, Mysore *

SHRI GULZARILAL NANDA, Union Minister for Irrigation and Power, made an exhaustive survey of the power potential in India, in the course of his inaugural address to the Scond All-India Power Engineers' Conference, held at the Indian Institute of Science, Bangalore. He said that electricity had become the symbol of civilisation and a measure of the material progress of a nation and there is increasing recognition of its importance for agriculture and rural development. "We in India", Mr. Nanda said, "have during recent years made considerable advance in electrical development, both hydro and thermal, but atomic energy has also to be developed". The Minister disclosed that the Atomic Energy Department was actively considering the question of setting up a nuclear power station of about 140 M.W. capacity at a suitable place as an experimental measure.

Mr. Nanda said that with a predominantly agricultural population dwelling in the 560,000 villages, rural electrification assumed very great importance in our country. The number of villages served by electricity at the end of the First Five-Year Plan was however, only about 6,000 and, as this was low the Government has planned to carry electricity to about 10,000 more villages and small towns during the Second Five-Year Plan at an estimated cost of Rs. 75 crores. Even with this increase, the number of villages electrified would form hardly three per cent of the total number of villages in the country.

Referring to power development in the various regions in the country, Mr. Nanda said, regions like Orissa and Assam, with *per capita* consumption of 0·49 and 0·7 units respectively were far under-developed compared to other States like Mysore and Bombay with *per capita* consumption of 55 and 51 units respectively. An earnest endeavour has therefore to be made to even out the disparities of development progressively.

First Five-Year Plan.

Proceeding, the Minister said, "A total generating capacity of one million kilowatt was added during the First Five-Year Plan, bringing the total installed capacity in the public utility undertakings in India to 2·7 million kilowatts. Among the projects, taken up during the First Five-Year Plan and which are continued in the Second Five-Year Plan, are the Bhakra Nangal Project in which an installation of 450 M.W. of generating capacity will be

* Compiled from the Reported Speech of the Hon. Minister, by Sri S. Raman, Assistant Engineer (Electrical).

installed, the Ghandhisagar power station under the Chambal Scheme and the Rihand Project. The commissioning of the Hirakud Power station on the 13th of this month marks an important mile-stone in the progress of power development in the country. Twenty-five hydro-electric stations and 19 thermal power stations are to be undertaken in the Second Five-Year Plan, which would increase the installation capacity by 3·5 million kilowatts."

New Hydro-electric schemes.

Giving certain salient features of the Second Five-Year Plan, Mr. Nanda said "Among the new hydro-electric schemes taken up during the Second Five-Year Plan may be mentioned the Sharavathy Project which has immense possibilities. Installation of two units of 71 M.W. each has been proposed during the Plan period, but the ultimate capacity will be more than 710 M.W. Among the steam power stations programmed for completion during the Second Plan, the 150 M.W. station at Durgapur, the 90 M.W. station at Kovba, the 200 M.W. station utilising lignite fuel at Neiveli, and the extensions to the Bokaro and Trombay power stations are worth mentioning. The power generated will be conveyed from the project sites to the load centries by construction of 35,000 miles of transmission and sub-transmission high tension lines of voltages varying from 220 K.V. to 11 K.V. The total outlay on power projects in the public sector during the Second Five-Year Plan will be about Rs. 427 crores, as compared with Rs. 160 crores, in the First Five-Year Plan. The private electricity companies are expected to invest another Rs. 42 crores, in expansions to their installations.

When we look ahead, we can visualise a mounting demand for power in the country. We thought at the beginning of the First Plan that we should over a period of 15 to 20 years add seven million K.W. It appears to me that in actual fact, the increase may exceed twice that figure".

Harnessing of rivers:

Dealing with the necessity for a country-wide hydrological survey, the Minister said: "We have a number of rivers, large and small, spread throughout the country: and even though their flow is seasonal, considerable hydro-power can be developed, if they are harnessed properly. The need for a rational assessment of the hydro-electric power resources of our country was realised as early as 1917–18. The hydro-electric potential of the Indian sub-continent based on the minimum flow was estimated at only 3·5 million K.W. In view of the rapid expansion of the power supply industry, it was found necessary to undertake a more systematic study of the hydro-electric potential of the country. The preliminary surveys of West-flowing and East-flowing rivers, the Central India rivers and the Ganga basin have been completed and the work in other areas is in progress. It has been estimated that the hydro-power potential of our country is of the order of 25 million K.W."

Thermal power resources.

With regard to our thermal power resources and the need for atomic energy, the Minister continued;

"The known reserves of metallurgical coal in India are of the order of 2,700 million tons only, the reserves of non-coking and steam coals have been estimated at 40,000 million tons. Besides, substantial quantities of lignite are available in South India. It will be reasonable to assume, that for several decades to come our resources of coal will be adequate to meet our requirements."

Nuclear power.

Explaining the necessity to augment our power resources by nuclear power development, the Minister continued :

"While it is a matter of satisfaction that we have sufficient hydro-electric and thermal power resources for meeting our requirements for some decades to come, it is, nevertheless, important that we should keep ourselves abreast of the modern techonological developments in other countries. The scientists and engineers of Western countries particularly of the U. K., and U.S.S.R., are actively engaged in harnessing nuclear energy for the production of power. A 5,000 K.W. nuclear power plant was commissioned in the U.S.S.R. a few years ago, and recently the Calder Hall Nuclear Project supplying some 50 to 60 M.W. of power to the electricity grid in U.K. was brought into commission. In due course, the output of this station is expected to exceed 100 M.W. The British Electricity Authority have programmed to establish nuclear power stations totalling 300 M.W. in capacity, in different parts of the country. We have adequate resources of radioactive materials in our country. As an experimental measure, the Atomic Energy Department are actively considering the question of setting up a nuclear power station of about 140 M.W. at a suitable location in India. The generation of energy at this station may be costlier than hydro or thermal power generated in a large modern high-pressure station. However, in due course, improved techniques and designs are expected to bring down the cost of power generated in a nuclear station to a level, comparable with the cost of generation, in a conventional thermal power station located at some distance from the coal fields."

Explaining the decision to establish a heavy electrical factory at Bhopal, the Minister said, it was a step in the right direction, as the manufacture of heavy plant and machinery is an important aspect of power development, which is absolutely essential for the success of our future plans. Mr. Nanda, concluding his speech, said that the power engineers of India had a creditable record in the past and he hoped that achievements of a much higher order awaited them in the future.

Late Sri G. Sundaram.

By the EDITOR.

IT IS WITH DEEP REGRET that we record the death of Sri G. Sundaram, the late Chief Engineer for Electricity, and Consulting Engineer to Government, on the night of 2nd March 1957, at his residence in Madras. A few days before, on 9th of February he had a heart attack, but he rallied round and was observed to be improving. His end came, however, suddenly on 2nd March, following a recurrence of heart attack.

Sri Sundaram graduated in the Presidency College, Madras, and after completion of his electrical engineering studies at the Institute of Science, Bangalore, had his practical training in United Kingdom and Europe. He was appointed as Hydro Electric Expert to the Chief Engineer for Irrigation by the Government of Madras in January 1926. In 1927, he joined the Electricity Department formed by Sir C. P. Ramaswamy Iyer with Sir Henry Howard, as its Chief Engineer. He served the Department in various capacities and became its Chief Engineer in 1944, and held that post for a period of 10 years. After retirement, he was Consulting Engineer to Government from 1954 to 1956. He served the Department for a full period of 30 years, with unparalalled devotion and distinction.

Sri Sundaram was responsible for the high technical and administrative standard of the Electricity Department. He served also as Adviser and Member of several Committees connected with electrical development of the country. He was a member of Kosi Project Committee and the Heavy Electrical Plant Committee and was appointed recently as Member of the Heavy Electrical Industries Committee. The present Chief Engineer and Senior Officers of the Department, who have had opportunities of working in close collaboration with Sri Sundaram, know him not only as a strict but sympathetic Officer, but also as a gentleman of wide learning and magnetic personality. The whole Department bemoans the loss of Sri Sundaram.

The Officers and Staff of the Department met on 4th March at the Office of the Chief Engineer for Electricity and paid their tributes and respects to Sri G. Sundaram. Sri V. P. Appadurai, Chief Engineer for Electricity presided and the following resolution conveying heartfelt condolences of the entire Department to Sri Sundaram's family, in their bereavement, was passed :—

"We, the members of the Electricity Department of the Government of Madras, wish to

LATE SRI G. SUNDARAM.

express our deep sorrow at the sudden demise of Sri G. Sundaram, who, until his death continued as friend, philosopher and guide of the Department.

"We record our admiration and pay our tribute for his selfless work, indefatigable devotion to duty and distinguished services to the Madras State as Chief Engineer and Consulting Engineer of the Electricity Department, and to the Government of India as Adviser and Member of several committees connected with electrical development and electrical industries in the country.

We convey our sincere sympathy and heartfelt condolences to the members of his family in their sad bereavement and irreparable loss."

Sri V. P. Appadurai, Chief Engineer for Electricity, commencing the proceedings spoke of his close association with Sri Sundaram, and how the standard of electrical development in the State had been advanced by Sri Sundaram. The Chief Engineer said—

"Gentlemen, we have met here today, under a sudden gloom, to bemoan the loss of Sri G. Sundaram who was snatched away from us unexpectedly on the night of 2nd March 1957. I was told a few days back that he was ill, but that he was improving. Then, on Saturday night I got the shocking news that Sri Sundaram had suddenly died. We immediately went and saw him. Nobody could believe he was dead.

"At the time of his death, Sri Sundaram was 60 years of age. He was associated with electrical development of the State even before the formation of the Electricity Department. From 1926 he was attached to the Irrigation Department as Hydro-Electric Expert. When the Electricity Department was formed in 1927 with Sir Henry Howard as Chief Engineer, he joined it right from the beginning and was a close associate of Sir Henry. He became an Executive Engineer in 1932 and later Superintending Engineer. In 1944 he became the Chief Engineer and continued as such till 1954. His services were extended as Consulting Engineer to Government till 1956 when he retired from the service. When I expressed our feeling, that he may be continued in service for some more time, he told me that he had served the Government of Madras and the Department to the fullest extent, and that he would always be available for consultations and advice at any time, when needed. He was a tower of strength to the Department and his passing away is a loss to the Department, and a very great personal loss to me. He was a great man of simple habits, austere living, wide learning and above all a towering personality—always genial, courteous and open-minded, though strict in standards. It was a very great pleasure to serve under him. He was accustomed to work long hours in office and was indeed a hard task-master, as he naturally expected others also to give their best to the State. I always used to feel proud that I had the opportunity to work in close collaboration with Mr. Sundaram, a nice gentleman. I know some, or most of you, would feel on the same lines as I do, but my association with him was longer

and closer. When I was Junior Engineer he was Executive Engineer. When I was Assistant Engineer he was Superintending Engineer, Mettur, and whenever we met, he used to speak to me with a pleasant smile. That is because of the love of each other. When I became Superintending Engineer (Technical), he was Chief Engineer. People in the office of the Superintending Engineer (Technical) know how much he used to appreciate the detailed analysis of the Technical Branch.

" The encouragement he gave was largely responsible for the high standard of technical merit which has been attained by the Technical Branch.

" Mr. Sundaram was a very great man and by his courtesy and pleasant qualities easily endeared himself to anyone who came into contact with him. Engineers in India and abroad had a great admiration for him. When I went out to Canada, England, Germany, wherever I went, everyone enquired 'how is Mr. Sundaram ?' Such was his fame abroad.

" He was very closely associated with the electrical development of this country. A few days prior to his death, I had been to his house. He was enquiring about our projects and delivery position of materials and equipment for the Periyar and Kundah Schemes and expressed satisfaction at the progress that had been achieved in the various projects.

" I am sure anybody, who knows him or thinks of him, would certainly speak of the high order of efficiency that he had set up. For full 30 years he had rendered devoted service to the Madras State and that service was a distinguished one in all respects and fully recognized as such, not only by the Government of Madras but also by the Government of India. He was a member of several Committees of the State Government and Central Government including the Development Council for Heavy Electrical Industries. If today our Department enjoys a high reputation in respect of honesty, integrity and merit, I dare say, without any fear of challenge, that it is hundred per cent due to Mr. Sundaram.

" He could have gone to the Central Government on a high salary, at any time, only if he had wanted to. His devotion and loyalty to the Madras State was such, that he did never think of it. His only ambition was to put the Department at a high level of honesty and integrity and raise the standard of electrical development in the State and in this he did succeed. It is for us now to maintain that level and increase the standard of electrical development further.

" To me his demise is apersonal loss and a very great loss, too. I know how widely respected and loved he was in the entire Department. It is our duty to perpetuate his memory suitably in a befitting way."

The Chief Engineer, next moved the condolence resolution. Sri A. R. Narayana Rao, Chief Operation Engineer (North); Sri L. Ekambaram, Chief Electrical

Inspector to Government; Mr. Morren, Assistant Generation Superintendent, Basin Bridge; Sri S. Padmanabhan and Sri S. Krishnaswami, Divisional Engineers, Sri T. Govindan Nair, Assistant Engineer, Sri N. V. Srinivasachari, Deputy Chief Accountant, and Sri D. S. Ramachandran, of the Chief Controller of Accounts Office, also spoke seconding and supporting the resolution and paying glowing tributes to Sri G. Sundaram.

The resolution was adopted and Sri Appadurai, Chief Engineer, concluding the proceedings said:

"We all loved him. What we have now heard, it is the duty of us all, to remember. We should keep his ideals, as an example, and imagine that he is still here watching our activities. Mr. Sundaram and Sir Henry both are of the same stature. One brought electritity to the country and the other nourished it. If you are really interested in the development of the State, you would do well to follow the example of the late Sri G. Sundaram and endeavour hard to keep up the standard of the Department."

The Chief Engineer ended by saying that he understood the Madras Electricity Department Electrical Engineers' Association had a proposal to start a fund for a suitable memorial to Sri G. Sundaram and he felt sure every member of Department will contribute liberally to the fund.

The gathering stood in silence for two minutes and paid their homage to the deperted soul.

All the Departmental offices were declared closed for the day as a mark of respect to the memory of Sri Sundaram.

Progress During the Quarter Ending 30th September 1956.

Salnent Features.

The inflows into the Mukurti, Pykara and Mettur Reservoirs were good during the quarter. The Reservoirs were almost full. The inflows into the Papanasam Reservoir were however poor.

Karaikudi and Devakottai electrical undertakings were taken over by Government on 1st September 1956.

The Department earned a revenue of Rs. 187·78 lakhs. The working expenses including suspense amounted to Rs. 82·98 lakhs. The capital expenditure during the quarter amounted to Rs. 207·27 lakhs.

Supply was extended to 3,260 agricultural, 273 industrial and 8,541 domestic services during the quarter. Villages totalling 343 were electrified, and 481·7 miles of H.T. and 645·5 miles of L.T. lines were erected and energized, during the quarter.

Under the South Kanara Scheme, Jog Power supply to South Kanara district was switched on 7th July 1956 by the Chief Minister of Mysore.

Construction Branch.

Madras Plant Extensions.—The I Stage extensions had all been completed and the equipments commissioned.

Under the II Stage extensions, most of the works were over except for the 5th boiler, which was under erection.

Under the III Stage extensions, construction of plinths and filling in with concrete over slab in boiler house were completed. In turbine house, nearly half of earth work excavation and placing of reinforcements was completed. Levelling of site for file foundation of I.D. cooling towers was completed.

Periyar Hydro-Electric Scheme.—Roads to surge shaft, upper camp, lower camp and power house were completed. The permanent bridge in the Power House road and Railway siding at Theni were completed.

The works for II Stage diversion of irrigation flow were completed. Excavation in forebay dam and masonry work in the spillway portion were progressing. In the scour vent, R.C.C. slab was completed for a length of 115 feet.

Excavation of power tunnel was completed and concrete lining of the tunnel was commenced. Sinking of surge shaft and excavation of pipe tunnel were completed. Grading of penstock was nearing completion. Excavation for anchors was completed, and that of power house and tail race was nearing completion.

Kundah Hydro-Electric Scheme.—In Kundah and Emerald camps contruction of labour lines and staff camp was progressing. In the Kundah camp excavation for grading penstock No. 1 and benching site in Power House No. 1 were progressing.

In the Emerald camp, excavation for foundation flanks of the Emerald and Avalanche dam was progressing. Excavation for coffer dam was completed and masonry for coffer dam was in progress.

Transmission Lines.

(*i*) *Salem—Namakkal* 110 *K.V. Line.*—The construction of the line had already been completed. In the Rasipuram Sub-station. building works were completed. Structure foundation was nearing completion. In the NamakkalSub-station building works were completed as also the structure foundations.

(*ii*) *Singarappet—Vellore 66 K.V. Line.*—All works were completed except crossing spans near Virinchipuram and terminal at Vellore substation. D.C. tests were conducted on 14th September 1956 for Singarappet-Virinchipuram section and line from Singarappet to Vadakethipatti Sub-station charged on 16th September 1956 and Vellore load was taken by the 2nd circuit.

(*iii*) *South Kanara Scheme.*—All major works connected with the scheme were completed.

(iv) *Villupuram-Pondicherry 66 K.V. line*.—Eighty per cent of excavation, stub-setting, concreting and 50 per cent of earthing were completed. Erection of Pondy Sub-station was progressing.

(v) *Periyar Transmission Lines*—(a) *Periyar-Theni 110 K.V. D.C. line*.—Excavation, stub-setting and concreting were progressing.

(b) *Theni-Madurai 110 K.V. D.C. Line*.—Excavation, stub-setting and contreting were progressfng.

(c) *Theni–Sembatti 110 K.V. D.C. line*.—Tower erection was under progress.

Works on the sub-stations were in various stages of progress.

Operating Systems.

HYDRO SYSTEMS.

(a) GENERATION.

The Mukurthi, Pykara and Mettur Reservoirs had good inflows during the quarter, and they almost reached their full capacities. The inflows into the Papanasam reservoir were hower poor.

All the systems were running in parallel during the quarter.

The load conditions in the systems and power houses were as follows :—

Name of System/Station.	*Station peak load in M.W.*	*Units generated in millions.*	*System peak load in M.W.*
(1)	(2)	(3)	(4)
Pykara	70·2	91·034 }	65·85
Moyar	36·5	32·628 }	
Mettur	42·9	84·332	68·86
Papanasam	28·0	32·024 }	29·20
Madural Thermal Station.	12·1	5·264 }	

The following services were connected during the quarter :—

System.	*Agricultural.*	*Indutrial.*	*Domestic.*
(1)	(2)	(3)	(4)
Pykara	882	70	2,932
Mettur	1,266	42	1,601
Papanasam	403	54	2,279

Pykara Power House.—Annual overhual of No. 4 generator and No. 4 transformer was completed. Work on carrier current communication was progressing.

Moyar Power House.—The installation of mulsifyre fire protection system for oil house was completed. The erection of out-door carrier current communication equipments was completed.

Mettur Power House.—Carrier current communication works were completed. Mulsifyre protection works were progressing.

(b) DISTRIBUTION.

Pykara Electricity System.—Work on the Madukkarai–Palghat 66 KV line was continued. Seventy-nine major extensions were completed during the quarter. One hundred and twenty major extensions were in various stages of progress.

Mettur Electricity System.—The Mettur Workshops manufactured tower and line materials to a total value of Rs. 33·71 lakhs.

The Vettavalam–Tirukoilur 11 KV line was charged over to 22 KV operation. Carrier current communication equipments were erected at

Singarappet Sub-station. The Polur-Arni 33 KV line was charged at 66 KV on 20th September 1956. Chengam 33/11 KV Sub-station and Hosur 33/11 KV Sub-station were commissioned.

Papanasam Electricity System.—Melakkallur permanent 66 KV Sub-station was energized on 13th July 1956. The newly constructed 11 KV line to Shermadevi was energized. H.T. supply to Manimuthur canals was given. The Kalakad 33/11 KV Sub-station and Panagudi 33/11 KV Sub-station were commissioned.

Karaikudi and Devakottai Electrical Undertakings were taken over by the Department on 1st September 1956.

Thermal Systems.

Madras System.—The load conditions were as follows :—

Name of Station.	*Station peak load in M.W.*	*Units generated in millions.*	*System peak load in M.W.*
'A' Station ..	20·9	20·672	43·8
'B' Station ..	21·0	21·938	..
Total ..		42·610	43·8

The following services were connected during the quarter :—

Agricultural	..	709
Industrial ..	..	107
Domestic ..	..	1,721
Total	..	2,537

The Madras System was giving relief to hydro-areas during the quarter.

The following are some of the major works attended to during the quarter :—

(1) High Tension Supply to All-India Radio, Avadi.

(2) Erection of 33 KV Poonamallee—Guduvancheri line.

(3) Erection of Chingleput-Tirukalikundram 33 KV line.

(4) Erection of 33 KV line from Madurantakam to Villupuram.

(5) Erection of Kanchi-Kadambatur and Kanchi-Wandiwash line.

(6) The new Sembiam 33/11 KV Substation was commissioned on 26th July 1956.

Besides these, 167 major construction works were taken up during the quarter and were in various stages of progress.

Six hundred and seventy eight D.C. services, with a total connected load of 719 KW, were changed over to A.C. during the quarter.

The works connected with the Madras Development Plan were in various stages of progress.

Rural Electrification.

The number of villages electrified during the quarter in the several systems, was as shown below :—

Pykara System	..	130
Mettur System	..	64
Madras System	..	89
Papanasam System.		60
Total	..	343

The lengths of lines erected and energised during the quarter were as follows :—

System.		*H.T. in miles.*	*L.T. in miles.*
Pykara ..	..	107·18	274·40
Mettur ..	..	195·76	173·27
Papanasam	..	38·80	83·91
Madras ..	..	139·94	113·92
Total	..	481·68	645·50

Accounts Branch.

The *Department earned* a *revenue* of Rs. 187·78 lakhs during the quarter. The working expenses including suspense during the quarter amounted to Rs. 82·98 lakhs.

The capital expenditure during the quarter amounted to Rs. 207·27 lakhs as compared to Rs. 91·20 lakhs in the previous quarter.

Technical Branch.

(*A*) ELECTRICAL.

Under the Kundah Hydro-Electric Scheme, the detailed specifications for turbines and generators and the specifications for power transformers received from Canada were examined.

Specification for outdoor and indoor switchgear for Basin Bridge and Villivakkam Substations was issued.

Local purchase orders were placed to the extent of Rs. 17·20 lakhs.

One hundred and thirty-six extension proposals amounting to Rs. 1·34 crores and 15 improvement proposals costing Rs. 2·73 lakhs were scrutinized during the quarter.

(*B*) CIVIL BRANCH.

(i) *Periyar and Kundah Schemes*—Under the Periyar Hydro-Electric Scheme, contract document for irrigation tunnel and supply of gates for forebay dam work was prepared. Shuttering and concrete proposals for surge shaft and pipe tunnel and concreting proposal for the re-inforced section of the pressure tunnel were finalised.

Under the Kundah Hydro-Electric Scheme, the proposals of the Canadian Government for control works of Avalanche and Emerald and Upper Bhavani were scrutinised. Tender specifications for the supply of mobile cranes, etc., for tunnels I and II and penstock No. I were analysed.

(ii) *Investigation of Schemes—Palar—(a) Porandalar Hydro-Electric Scheme.*—Reconnaissance of the Porandalar valley was progressing. Reservoir survey was completed. Dam site survey was progressing for Gunda Reservoir.

(*b*) *Mettur Tunnel Scheme.*—The Central Water and Power Commission was addressed for information regarding safe limits for blasting operations in connection with left flank scheme. Right flank scheme investigations were progressing.

(iii) *Hydrological data.*—Collection and compilation of rainfall and run-off figures of the various basins were continued. The number of rainfall stations was 532 at the end of the quarter. Run off statistics were being collected from 35 river flow stations. Evaporation and meteorological observations were being conducted in four stations.

In the Nilgiris area, work on construction of eight measuring weirs was in progress.

Technical Press

Preview of the next 25 years.

—By David Sarnoff.

The Dominant physical fact in the next quarter-century will be unprecedented technological progress. The harnessing of electricity, the development of electronics, Television T.V. magnetic recorder and the splitting of the atom are the highlights of the last 100 years' inventions. There is no longer any margin for doubt that whatever the mind of man visualizes, the genius of modern science can turn into fact. Scientists are now engaged in the development of a new form of light, electronic light, which is the keystone of the light amplifier under development in RCA laboratories. Already this light amplification is experimentally more than 20 times the original. When that number 20 reaches 100, we shall have a practical amplifier of light. It is expected to lead to devices that will make vision possible in darkness, and it will immensely enlarge our visual penetration of outer space.

The era of nuclear power for civilian purposes is already at hand. Just an year ago the Radio Corporation of America publicly demonstrated an atomic battery. Only a minute amount of electric current was generated. But the potentials of that event are enormous. This was no longer the use of atomic energy to make steam to make electric current—it was the direct conversion of nuclear energy into electricity.

I do not hesitate to forecast that atomic batteries will be commonplace long before 1980. The waste products from reactors will supply abundant captive radiation for direct conversion into electricity. Ships, aircraft, locomotives, even motor-cars will be atomically fuelled. Guided missiles, transcontinental and trans-oceanic, will transport mail and freight over great distances, guided into terminal hangars within minutes after their take-off.

Great fleets of private helicopters and pilotless planes will make the principal airways busy and electronic controls will ensure safe travel in both directions. Other sources of energy the sun, tides and winds are certain to be developed beyond present expectations. Fresh water, purified from the briny seas, will enable us to make deserts flourish. The ocean floors will be harvested for chemical and food resources.

The era of " automation " is upon us, and automatic equipment and scientific advance will put a premium on brains rather than brawn. A much shorter working week will no doubt prevail in 1980, and another ten or fifteen years will have been added to the average life-span. No labour but leisure will be the great problem. We have reason to foresee a fantastic rise in demand for and appreciation of the

best in art, music and letters. Television will be world-wide.

World law enforced by world police seems inherent in the age of science and technology. Our supreme commitment, must be to win a genuine peace rooted in liberty.

"*Readers Digest*",
April, 1955.

Electrical Accidents in Britain.

The report of H.M., Senior Electrical Inspector of Factories for the year 1954, covering electrical accidents was published last autumn. The table of reportable accidents shows there were 707 accidents, fatal accidents numbering 33. Although the annual totals very irregularly a definite downward trend is discernible for both fatal and non-fatal accidents, and if this is considered in conjunction with the rapidly increasing use of electricity, a more favourable light can be thrown upon the general effectiveness of safety measures.

The proportion of accidents, caused by portable apparatus, accounts for 45·5 per cent of the reportable fatal accidents and 35·1 per cent of the total accidents. It cannot be said any lessening trend is in evidence. Either the lack of, or the failure of, earthing systems accounted for 26·6 per cent of the 302 accidents involving electric shock.

The analysis of accidents in relation to voltage shows that 19 of the reportable fatalities occurred at 250 V and below. In his general comments, the Senior Inspector calls attention to the surveys of network short circuit conditions, that have revealed inadequate breaking capacity of associated switchgear.

The number of reportable accidents caused by human failure such as forgetfulness, negligence, care-lessness, inadvertence, or ignorance is about half the total, excluding cases of welding eye-flash.

In dealing with typical accidents and dangerous occurrences, in electricity supply, the Inspector emphasizes instances, where lapse of memory or mental aberration on the part of fully competent personnel has resulted in serious accidents.

The report also makes the usual survey of accidents and dangerous occurrences in the industrial applications of electricity. In this connection the comments concerning the use of portable apparatus and earthing systems are well worth close study.

"*Distribution of Electricity*"
—*January* 1957.

The London Post Office Railway.

Few people know that there is a tube railway run by the General Post Office. Forty, trains an hour travel on this railway, without drivers or guards. They carry only letters and parcels.

The railway runs through 6½ miles of tunnel at an average depth of 70 feet below ground and it is the only railway of its kind in the world.

Costing a million and a half pounds, the line was opened to traffic in December 1927. The gauge of the tracks is only 2 ft., and while the stations themselves

are roomy, the main tunnels, which carry both east-bound and west-bound tracks are only 9 feet, in diameter. This is reduced to 7 ft., at the station approaches, where the tunnels divide into two.

At each station, the tracks branch out into four platform roads. The inner tracks, next to the platform, are used for stopping trains, and the outer tracks for non-stopping-trains. The length of the station platform varies, the shortest being only 90 feet and the longest, 313 feet at Mount Pleasant.

Vehicles, of which there are 50, have a carrying capacity of 1 ton 16 cwt. each. They are mounted on 8 wheels, of which the leading and trailing pair are coupled to 22 h.p. motors. In case of break down between stations there are three battery locomotives stationed on short sidings at three points along the line.

In the absence of drivers and guards the operating methods of the railway are unique : thus signals are un-necessary. The line is track-circuited throughout, like an ordinary tube railway, and no train can enter an occupied section. The trains are controlled in station limits, by the signalmen or rather switchmen.

The sections between stations are fully automatic, that is, the track is permanently energized unless the next section ahead is occupied, when the track is made dead through the agency of the track circuits. The switchmen can make the sections dead in case of emergency. When a train is despatched it arrives upon he automatic section and if this is "alive" the train proceeds at a speed of about 35 miles per hour until it arrives outside the next station, where it runs on to a dead section and stops automatically.

The breaks on the trains are applied by means of powerful springs. When the train is started, a powerful electromagnet is energized, which releases the brakes against the resistance of the spring. On arriving at a dead section the magnet is de-energized and the brakes are applied by the springs.

Interlocking is carried out in exactly the same manner as on ordinary railway signalling systems. The points are worked by compressed air motors and a train cannot be admitted on any station section, unless the line is clear, and the points are correctly set and locked.

The average daily traffic requires the handling of about 37,000 mail bags.

The Post Office Railway is a fine example of civil and electrical engineering and an achievement of which London can be proud.

"*Distribution of Electricity*"
—*January* 1957.

Rates and Costs Committee.

India initiated an integrated process of economic reconstruction, by embarking upon a number of river valley projects, with a view to stepping up agricultural production, power generation and a fair degree of flood moderation and control. These project executions, of course, entail colossal expenditure in the public sector. The frequent upward revision of the project estimates and the conspicuous lack of uniformity in the unit rates for most of the

items of work on the several projects prompted the Union Ministry of Irrigation and Power to effect substantial economy in the several executions undertaken, by determining a basic schedule of rates, which will enable the preparation of project estimates, with a reasonable degree of reliability, and laying down suitable remedial measures for an efficient cost control. With this end in view, the Union Ministry appointed an Expert Committee under the Chairmanship of Shri P. C. Agarwal, Retired Chief Engineer, Uttar Pradesh, to analyse the working of the different projects and report their findings and recommendations.

The Rates and Costs Committee started their deliberations early in 1954. The report of the Committee is in two parts, the first pertains to the preparation of estimates, requirements for a satisfactory analysis of the several items of work in the execution of river valley projects, and a uniform cost control organization for adoption on projects. The second part deals mainly with Stock Account Rules, standard forms for the maintenance of stores, special tools and plants and modifications to Public Works Department forms to have better cost accounts.

The break-up of the estimates into several items of work and further splitting up of each item into its ultimate constituents of men and materials, exemplified in the report, enable a realistic appraisal of unit costs.

The Committee are generally of the opinion that adoption of machinery in construction is a necessary adjunct for sound economic development of the country, and make a strong case for the manufacture of machinery in the country.

The importance of a well-maintained stores and store accounts have been fully emphasised by the Committee. While pointing out the inadequacy of the existing practice, adopted in some of the river valley projects, the Committee make a strong plea for a standardised procedure regarding classification and codification of stores, procurement, accounting of receipts, issues, and balances, stock-taking, payments for stock receipts and periodic pricing of the stores, the quantity and value accounts and efficient management.

The accurate and realistic framing of firm estimates for projects is vital for effective cost control, the essential requirements being a schedule of basic wages and material rates, transport charges, equipment cost and hire charges.

The report exhaustively covers important items of work in river valley construction, such as, excavation, loading, hauling and compaction units; earth-work by human labour; transport; drilling and quarrying; tunnelling; brick-work and lining of canals; steel works and gates; stone masonry and concrete and form work.

"*Bhagirath*"
—*November* 1956.

Visit to Russian Hydro Installations.

Sir John Hacking and other members of the British delegation of hydro-power experts, which recently toured European Russia, inspecting various hydro-electric

installations, gave an interview to the electrical press.

Sir John said that on 10th October they flew into Moscow, where they stayed for two days and then south to Erevan, near Lake Sevan. This lake was being reduced to a level of one-sixth by evaporation in 50 years, and the 600 MW hydro station, which it would serve, was one of eight cascade stations. On 15th October they visited the undertaking on the River Kharam, where there was a 113 MW station in commission, a second station under construction and a third station projected. They then flew to Stalingrad, which had the lowest of the stations on the Volga. There were three old stations in commission, north of the Volga, and Kuibyshev station, under construction would have a capacity of 2,000 MW.

On 19th October they flew west and over the lake created by the Kakhovka power station. This lake would have a storage capacity of 6,000 million cu. m. and a capacity of 312 MW; the overall head was 27 m.

During the tour, they saw various research laboratories, including one in Moscow, and they visited a number of factories, including one in Leningrad, where turbines were produced. In the Moscow laboratory research in turbine design was being carried out and the changing of blade pitch seemed to be most useful work. They also worked on stresses and on a duty of underwater sluices, the effects of water hammer and stresses on alternator shafts. They got the firm impression that Russian planning was sound.

It seemed that the Russians did not think that unclear energy would influence the development of the hydro work to any appreciable extent.

The delegation understood that the European, hydro development would be finished in 1965 and that by 1960, the output from the hydro stations would be something like 59,000 million kwh, which would be 80 per cent of the total output of all the stations, that is, hydro and thermal stations.

The Russians seemed to have got the "know-how" of establishing dams on permeable soil. The Russians were putting up stations very quickly; 3½ years was a reasonable time for a sizeable station with all round the clock working, this representing mechanisation on a really large scale. A more general note was the enthusiasm with which the Russians showed their visitors their new towns, particularly the amenities—sports fields, theatres, and concert halls.

"*Electrical Review*"

—*November* 1956.

High Voltage Testing Equipment for Australia.

During the past few years Henleys have installed numerous cable systems and it was therefore decided to augment the equipment for site commissioning by providing testing apparatus, as versatile as possible For this purpose a 25 cwt-commer van has been equipped with all the necessary apparatus for applying high-voltage tests to cables and overhead lines after installation and for localizing the various kinds

of faults in underground systems such as ordinarily occur. The high-voltage apparatus is designed to cater for system voltages up to 33 KV. The high-voltage equipment is designed for a nominal output of 80 KV. d.c. at a continuous current-rating of 5 ma.

The voltage doubler circuit is employed for testing cables designed for unearthed neutral working. The voltage regulator can vary the input voltage of the step-up transformer continuously from zero to 220 V. To obtain the maximum output voltage to earth one terminal of the high-voltage winding of the step-up transformer is connected to one of the capacitor terminals the other of which is earthed ; the other terminal of the high-voltage winding is connected to the junction of the two series-pairs of rectifiers. The positive terminal of the rectifier bank is earthed through a resistor, while the negative terminal of the bank is connected to the cable or apparatus under test. This arragement will give output voltages up to 100 KV., provided the leakage current is small.

For cables designed for solidly earthed neutral systems, the circuit is used with one terminal of the high-voltage winding of the transformer earthed. The rectifier circuit then consists of two half-wave rectifying units of opposite polarity, so that the voltage applied between the conductors is double,that applied between either conductor and earth.

The connections between the testing set and apparatus under test are made with polythene insulated single-core leads, which have an outer metallic earthing screen. This enables connections to be made without the need of any special protection or provision for sufficient clearances, such as are necessary, when bare or lightly insulated connections are used.

All the metal parts of the van including the body and lighting fittings are bonded electrically to the earthing bus-bar, which is connected to an effective earthing electrode when high-voltage tests are to be made.

The control desk is fitted in a forward compartment of the van to which the normal driver's cab doors give access. This compartment is completely isolated from the body of the van containing the high-voltage equipment by a wooden partition excepting for the windows through which the operator can observe the high-voltage voltmeter and milli-ammeters. The partition is faced with a metal screen connected to the main earthing bus-bar.

At the centre rear end of the van floor, three large earthing terminals connected to the earth busbar are provided, two of which are used for the earthing rods for discharging cables on the completion of high voltage tests. The third terminal is used for the main earth connection.

A comprehensive range of instruments is carried in a cupboard in the operator's compartment behind the driver's seat. These instruments embrace a slide-wire and galvanometer for Murray loop tests, suitably insulated for use in conjunction with the high-voltage equipment for localizing high-resistance faults, capacitance/inductance bridge for localizing open-circuit faults, a Wheatstone bridge, flashing-fault localizer, megger, and avo-meter,

An autotransformer is also provided which will boost mains-supply as low as 200 V for energizing the high-voltage testing equipment and also give a 220 V supply from a 110 V source.

" *Distribution of Electricity* "

—*September* 1956:

Tit-Bits.

Song in praise of Electricity.

The increasing availability of power to lighten the drudgery of work led an American house-wife to sing in praise of electricity as under :—

When I consider how my
mother spent,
Her waking hours in health
destroying tasks,
Careful to show the smiling
face, that masks,
Rebellion, in the heart; but
still intent,
To serve her family and to
them present,
A smoothly running household,
though her cares
Were stealing youth and beauty
unawares,
But, knowing nothing better
was content;
Then, am I thankful, that I live
today,
When cheap *electric power*
does for me,
In half the time, with half
the energy,
The job that stole my mother's
youth away,
Time now is mine to be
companion, friend,.
To understand, advise and
to commend.

Corrosion of Aluminium.

The Corrosion of aluminium in water at high temperatures is being studied at the Argonne National Laboratory. Serious corrosion was observed, but the corrosion resistance was remarkably improved when small quantities of certain inorganic salts were added to the water. The same effect was observed in neutral solution and in slightly acid solution.

Hot Suit.

A suit that enables a man to work in temperatures one-eighth as hot as the sun's surface was demonstrated in New York recently. The demonstrator six times entered an industrial furnace heated to 1,200 degrees Fahrenheit, the highest temperature ever entered publicly for more than a few seconds. He stayed two or three minutes each time, as if on a repair or rescue mission. The demonstration sponsored by Minnesota Mining and Manufacturing Company, St. Paul, was held to show the heat protective qualities of fabrics, coated with a thin layer of aluminium. The aluminium-coated fabric reflects radiant heat instead of insulating against it. Nine-tenths of the heat is reflected away by the aluminium coating: and what gets through is dissipated by a layer of glass fibre—quilting beneath the aluminium coating.

" *Al-ind Abstracts* "

—*December* 1956.

First Atomic Reactor.

August 4, 1956 will be a date for history books. On that day, at 3-45 p.m. the first atomic reactor in India went into operation at Trombay, 7 miles from Bombay. The reactor, with a capacity of 1,000 KW, is of the swimming pool type. It is housed in a hall 100 ft. long, 50 ft. wide and 79 ft. high, the rectangular concrete tank forming the pool being 28 ft. by 10 ft., 28 ft. deep. The core consists of 25 to 30 fuel elements containing Uranium 235 sandwiched between two plates of aluminium. The reactor has cost about Rs. 27 lakhs and is the first of several atomic projects now being undertaken by the Atomic Energy Commission for the ultimate purpose of generating power from the country's nuclear resources. An experimental reactor of NR–X type is under construction at present and is scheduled for completion by 1958. It will have a capacity of about 5,000 KW.

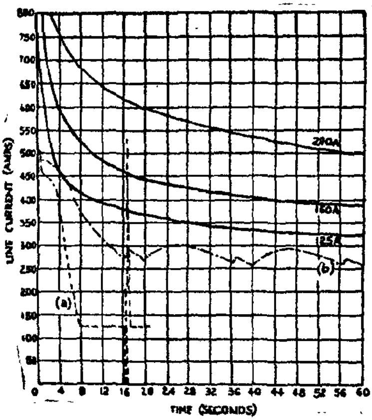
"*The Indian and Eastern Engineer*"
—*September* 1956.

Some Problems of Fuse Selection.

Rules for the selection of fuses are given in most manufacturers' technical data but such rules of thumb are intended to cover general cases. It is advisable for the user to acquiant himself with the reasoning behind such rules. Where possible he should determine the full characteristics of his load so as to be able to make adequate use of time/current characteristics.

It is much better for manufacturers to have a common standard, by which all their curves can be compared and such a standard is provided by the recommendations in the new B.S. 2692 of 1956 for high voltage fuses. This suggests the use of 'virtual times' on time, current characteristic curves, and the suggestion could apply equally to fuse characteristics in other voltage ranges. Virtual time is defined as the time during which a constant current equal to the prospective current would produce the same amount of heat, as the actual admitted or cut-off current does during the actual time. In other words the basis of comparison is the heat energy required to produce fusion, and this can be obtained experimentally for each fuse. By assuming a constant current equal to the prospective current, the time required to produce the heat energy of fusion can be calculated, and this time is called the virtual time. Fig. 3 shows the virtual time line plotted for comparison with the actual time area. Having determined the basis on which curves are plotted it is necessary to determine all factors in the characteristics of the load. For instance, it may be useless to try to apply a fuse, specially designed to give motor starting characteristics, to an application where frequent successive starts or frequent stallings are possible. An example will illustrate the correct selection of a fuse for a particular duty.

In Fig. 4, curve (*a*) shows the root mean square value of current during the starting period of a squirrel cage motor started by an auto-transformer starter. A direct comparison of this starting curve with the fuse characteristics shows that the initial peak lies below the curve for a 125-A fuse while a 200-A fuse is required to clear the second



peak. Such direct camparison however does not take into account the full effect of pre-heating due to the initial surge, while it exaggerates the effect of the second peak.

The starting current of the motor is not, of course, a steady current and at the time when the starting curve most nearly approaches the fusing characteristics after the initial peak, the fuse has already been pre-heated at a higher current. When the second peak occurs however, the r.m.s. value of the current which has flowed up to that time is much less than the value of the peak. Since this lower value of pre-heating current has flowed for a long time in comparison with the duration of the peak, the proportional increase in heat energy due to this second peak is negligible.

Curve (*b*) is a curve of successive r.m.s. values of curve (*a*), i.e., each ordinate of (*b*) is the r.m.s. value of that part of (*a*) which precedes it. This allows the full effect of pre-heating to current peaks to be taken *into account.* Furthermore, since the application was one, in which up to three successive starts could be expected, the precaution has been taken of plotting curve (*b*) to cover three starts. Comparing curve (*b*) with the fuse characteristics, it will be seen that the 125-A fuse characteristics cuts curve (*b*) while a 200-A fuse is unnecessary. The correct fuse rating for close protection of this motor is 160-A, provided the full load current of the motor does not exceed this value.

Circuits protected by fuses have many different features but it is hoped that the above will give some help in arriving at a correct rating of fuse. For difficult or unusual applications, it may be advisable to consult the supplier, and in such cases as much information as possible should be provided concerning the characteristics of the circuit.

"*Osram Bulletin*"

—*June* 1956.

Problem Corner.

Problem No. 3.

The problem offered this time is a simple arithmetical and geometrical one.

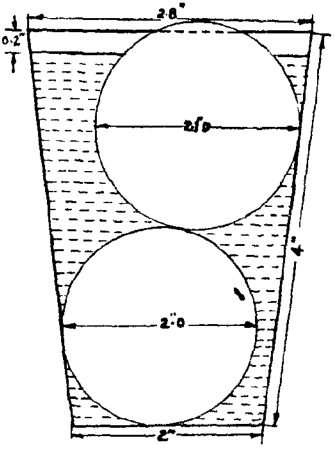
"One glass tumbler is of 2·8 inches internal diameter at the mouth: and 2 inches internal dia meter at the bottom. The slant height is 4 inches. Two hollow metallic spherical balls, one of 2 inches diameter: and the other of 2·1 inches diameter are placed inside, the former at the bottom and the latter at the top above it as shown in the diagram.

Water is poured in gradually to a depth, just 0·2 inch below the top level of the tumbler. If the empty tumbler weighs 3·4 oz. and bottom ball and top ball respectively weigh 2·5 oz.: and 2·625 oz. respectively, determine,

(*a*) the volume of water poured in; and

(*b*) the total weight of the whole arrangement".

This problem was suggested by Sri S. Raman, Assistant Engineer (Electrical).



Social and Personal.

The Chief Engineer returns back to India.

Sri V. P. Appadurai, Chief Engineer for Elecricity returned back from Canada on 26th January, 1957 and assumed charge as Chief Engineer.

Postings and transfers.

Sri N. R. Narasimhamurthy Chief Operation Engineer (South), proceeded on leave for two months and twenty days from 12th March 1957, *f.n*

Sri C. N. Devarajan, Assistant Engineer (Electrical), has been promoted as Divisional Electrical Engineer.

6 - MAY 1958

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